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Nearshore Fish and Macroinvertebrate Assemblages Along the Strait of Juan de Fuca Including Food Habits of the Common Nearshore Fish
Final Report of Three Years' Sampling, 1976-1979

(U.S.) National Oceanic and Atmospheric
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Prepared for

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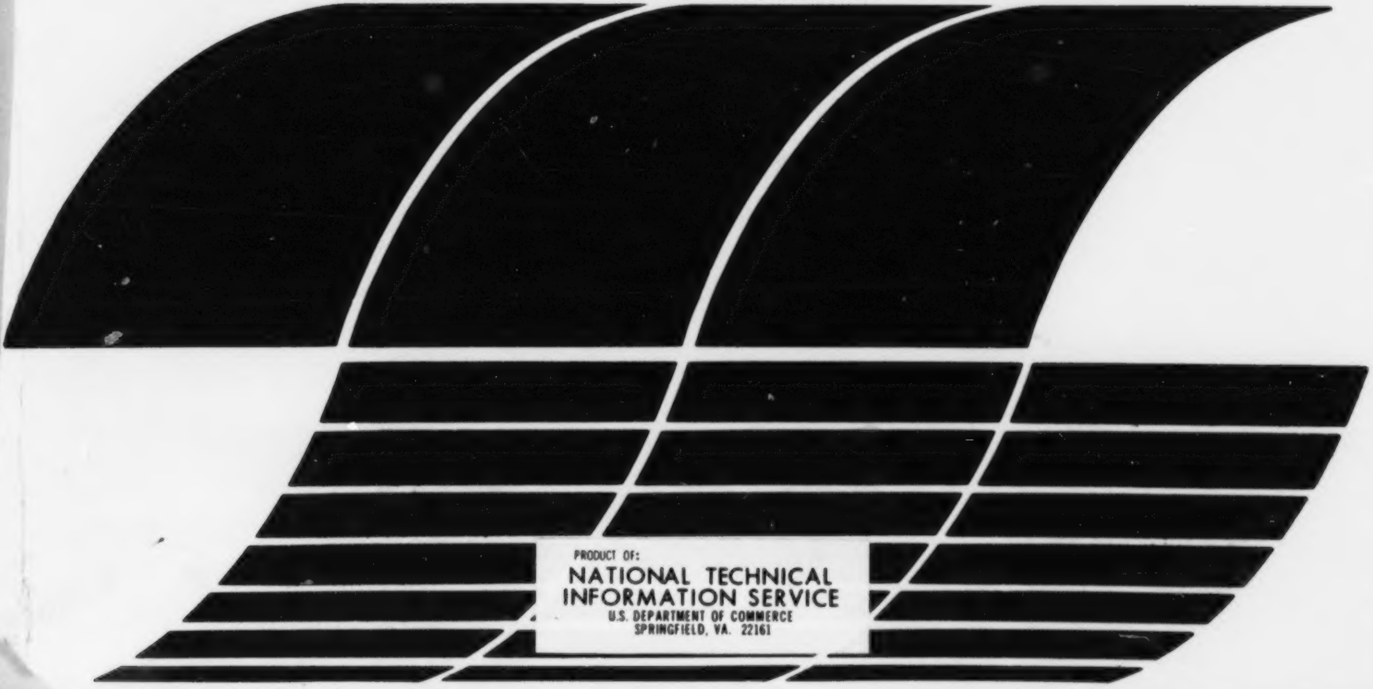

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NEARSHORE FISH AND MACROINVERTEBRATE ASSEMBLAGES ALONG THE STRAIT OF JUAN DE FUCA INCLUDING FOOD HABITS OF THE COMMON NEARSHORE FISH

Final Report of Three Years' Sampling, 1976-1979

by

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by

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ABSTRACT

A seasonal survey of nearshore fishes was made in the Strait of Juan de Fuca from May 1976 to June 1979. A beach seine was used for sampling nearshore demersal fishes and a townet for nearshore pelagic fishes; intertidal fishes were sampled with the use of anesthetic and a hand net. During 1976 - 1978, the macroinvertebrates caught incidentally in the beach seine and townet were also recorded. Data recorded for fish and macroinvertebrates were species present, life history stage (from size), abundance, biomass, food habits and presence of external abnormalities or disease.

The total number of nearshore demersal and pelagic fish species decreased from east to west in the Strait of Juan de Fuca but the total number of intertidal species increased -- however, it was postulated that this opposite trend was due to the same habitat relationship: species diversity increased as habitat heterogeneity increased. Nearshore demersal and pelagic fish catches were dominated by juvenile and larval life history stages, while intertidal collections were primarily adults and juveniles. There is little overlap between the nearshore demersal--pelagic fish assemblages and the intertidal fish assemblages, and there is no evidence that the rocky intertidal is significantly utilized by the common subtidal species as a spawning or nursery area.

Common nearshore demersal fishes were the flatfish and sculpins, while herring clearly predominated in the nearshore pelagic zone although smelt and Pacific sand lance were also important. The common rocky intertidal fishes were the sculpins and pricklebacks (i.e. "eel blennies").

Seasonal trends were pronounced in the nearshore demersal and pelagic fishes but largely absent in the rocky intertidal fishes. Nearshore demersal species were generally at their maximum (number of species, abundance, biomass) in the summer and at their minimum in the winter, although at the protected sites the maximum often extended from spring through fall. Nearshore pelagic species were at their maximum in the spring-summer and at a minimum in the winter.

The common fish species found in this survey were categorized into nine functional feeding groups based on their stomach contents. The most important food item found was epibenthic zooplankton for nearshore demersal fishes while pelagic nearshore fishes fed primarily on pelagic zooplankton. Size selection was indicated by fish preying on zooplankton.

This study was set up as a first time survey of the fishes of the Strait of Juan de Fuca. However, it also demonstrated that there is a great deal of variation from year to year, season to season, from site to site, and between hauls. How much of this is sampling variation and how much is natural biological variation was not determined, although we believe most is natural biological variation. To statistically use the data attained in this study to assess the result of a perturbation on nearshore fishes in the Strait of Juan de Fuca would require that the abundance of nearshore demersal fishes be decreased by about 75% to be detected, and would require that the nearshore pelagic fishes be decreased by about 95% to be detected. We believe the information is better used to help in predicting the results of various man-induced alterations proposed for the Strait of Juan de Fuca.

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SECTION 1

INTRODUCTION

The possibility of transport of Alaskan North Slope oil to proposed refinery and transshipment sites in the Strait of Juan de Fuca or Puget Sound has increased the probability of oil pollution in these waters. Under proposals presently being considered, oil could be transferred to refinery, holding, or pipeline facilities at one of a number of sites on the Strait of Juan de Fuca or the eastern shore of Rosario Strait.

The State of Washington and the federal government, concerned with minimizing the incidence and impact of oil pollution, have conducted a number of programs designed to evaluate the detrimental effects of oil pollution on the biological and economic resources of Puget Sound. One of these, the Washington State Department of Ecology's (DOE) Northern Puget Sound Biological Baseline Study (1974-76), focused on documenting biological communities in the nearshore habitats of northern Puget Sound (Miller et al. 1977).

When the eastern Strait of Juan de Fuca came under consideration as a possible oil transshipment terminal site, the National Oceanic and Atmospheric Administration's (NOAA) Marine Ecosystem Analysis (MESA) Puget Sound Project initiated similar biological baseline studies in the Strait of Juan de Fuca in spring 1976 and along the west coast of Whidbey and Fidalgo Islands in spring 1977. An important part of the NOAA studies is the ecological survey of nearshore fishes and their food habits. Nearshore, as opposed to offshore, fishes were emphasized because: (1) Nearshore habitats are more likely to be adversely affected by spilled oil than offshore habitats, and (2) fish provide a potential link to man for the transfer of hydrocarbons.

The principal objectives of this study were to document: (1) The occurrence, abundance, and distribution of nearshore fishes; (2) food habits of abundant and economically important species; and (3) occurrence and distribution of macroinvertebrates collected incidentally with the fishes.

Results of the first two years of investigation (May 1976 - June 1978) were summarized in a previous progress report (Cross et al. 1978). The present report summarizes the combined results of the three years of study (May 1976 - June 1979).

SECTION 2

CONCLUSIONS

A total of 94 species of fish (more than 200,000 individuals) was collected by beach seine, townet, and intertidal sampling between May 1976 and June 1979. The species richness of beach-seine and townet catches decreased during the study largely because of the absence of rare species and was not regarded as significant. In general, the species richness of beach-seine and townet catches decreased from east to west, while species richness of intertidal collections increased. In beach-seine and townet collections, this trend was attributed to decreasing habitat heterogeneity and relief, and increasing exposure to ocean storms. The opposite trend in intertidal collections was attributed to increased habitat heterogeneity and relief which provide suitable refugia from turbulence.

The assemblage of nearshore fishes sampled with the beach seine was quite diverse (81 species collected over three years) but consisted largely of juvenile fishes, reflecting the extensive utilization of nearshore habitats as nursery areas by many species inhabiting the region. Demersal species accounted for 69% (56 species) of the species collected. Sculpin (32% of the demersal species, 18 species) and flatfish (16% of the demersal species, 9 species) predominated in frequency of occurrence, abundance, and biomass. Pelagic species accounted for 31% (25 species) of the fishes collected. Pacific herring and Pacific sand lance often predominated in abundance and biomass, while seaperch (20% of the pelagic species, 5 species) and gadids (12% of the pelagic species, 3 species) occurred more frequently.

Seasonal trends in species richness, density, and standing crop of fishes in beach-seine collections were more pronounced at the exposed sites (Kydaka Beach, Dungeness Spit) than at the protected sites; maxima generally occurred in summer and minima occurred in winter. At the protected sites, maxima occurred from spring through fall and minima occurred in winter. The abundance and biomass of fishes collected by beach seine were poorly predicted when regressed against temperature, salinity, and dissolved oxygen measured at the time of collection.

The assemblage of neritic fishes sampled with the townet (60 species collected over three years) was not as diverse as the assemblage sampled with the beach seine and consisted largely of larvae and juveniles. Demersal species accounted for 62% (37 species) of the species collected. Pelagic species, while accounting for 38% (23 species) of the species collected, composed more than 95% of the total number and more than 90% of the total biomass of fish collected. Pacific herring, collected at all sites, accounted for 76% of the total number and 75% of the total biomass of fish caught. Longfin smelt accounted for 16% of the numbers and 11% of the biomass of fish collected and occurred almost exclusively at Pillar Point and Twin Rivers (99% of all smelt caught). The remaining 58 species composed 8% of the total number and 14% of the total biomass of fish caught.

Seasonal trends in species richness, density, and standing crop of fishes in townet collections were similar across all sites--maxima occurred in spring and occasionally summer, and minima occurred in winter. The presence of Pacific herring exerted the largest influence on this trend: Less than one percent of all herring were collected in fall and winter. The abundance of fishes collected by townet was poorly predicted when regressed against temperature, salinity, and dissolved oxygen measured at the time of collection. However, biomass was predicted fairly well by temperature (significant at six of the seven sites) but not by salinity or dissolved oxygen.

The assemblage of fishes collected in the rocky intertidal was composed solely of demersal species (26 species). Sculpin predominated in the assemblage (50% of the species, 13 species), followed by prickleback (19%, 5 species). Seasonal trends in species richness, density, and standing crop of intertidal fishes were largely absent. Unlike the nearshore and neritic fishes, intertidal fishes do not move into the subtidal during fall and winter but remain in the intertidal throughout the year. Furthermore, the fishes sampled by beach seine and townet were primarily juveniles; the adults of these species generally inhabit deeper water than the juveniles. The majority of intertidal species collected inhabit the intertidal as adults. The only evidence of seasonal trends in the intertidal species was the appearance of recently metamorphosed juveniles in late winter and spring, but their numbers were not sufficient to produce seasonal peaks in density or standing crop.

Significantly, the rocky intertidal is rarely utilized as a nursery area by the common subtidal species, probably because the environmental fluctuations experienced in the intertidal require specialized adaptations that would be of limited value to later life history stages spent in subtidal habitats.

The ability to detect decreases in the abundance and biomass of nearshore fishes was analyzed using power curves. It was found that the beach-seine data were better than the townet data for detecting decreases. For the beach-seine data, decreases must be in general 75% or more before they can be reliably detected; for the townet data they must be 95% or more. Using the beach-seine data, it is easier to detect changes in numbers than changes in biomass, and changes that occur in spring will be more difficult to detect than changes occurring in other seasons.

The 36 nearshore fishes, composing the most common or abundant species encountered along the strait,were categorized into nine functional feeding groups. The most prominent feeding mode was the obligate epibenthic planktivore, accounting for 15 species (42%). Facultative epibenthic planktivores included another eight species (22%). Thus, epibenthic zooplankton appear to constitute the trophic base of the majority of the nearshore fishes of the region. As most epibenthic zooplankton are either detritivores or herbivores on macroalgae, the annual cycle of production of nearshore macrophytes and seagrasses and conversion into detritus is the most important process determining nearshore food web structure and energy flow in the region.

Examination of variability in prey composition by year and habitat for 14 nearshore fish species indicated that although a limited number of prey taxa may be important in the diet spectrum of a species, the proportional contributions among the prey taxa vary considerably. This suggests that prey switching is probably a common occurrence but may be limited to a narrow component of the available prey community. In general, diet overlap was more consistent between years than between habitats (sites) although overlap values were equally variable in both cases.

Coincident sampling of epibenthic zooplankton during the August 1978 beach-seine and tidepool fish collections indicated that, while harpacticoid copepods predominated at virtually every site and microhabitat sampled, nearshore fish tended to feed upon the larger prey of the assemblage available to them. Accordingly, overlap between the plankton composition and prey composition of the co-occurring nearshore fishes was higher in comparisons of biomass than in comparisons of numerical composition. Even within a prey taxon, such as gammarid amphipods, size-selective predation upon the largest available amphipods was evident.

Conclusions regarding the composition, abundance, and biomass of macroinvertebrates collected incidentally during beach-seine and townet collections must consider that these collection methods were not designed to provide quantitative data for the macroinvertebrate assemblages. Accordingly, comparisons between years, sites, and seasons can be considered as only relative, qualitative differences in the macroinvertebrate assemblages.

In both years, species richness, abundance, and biomass of collected epibenthic (beach seine caught) macroinvertebrates were generally highest at the more protected sites, Beckett Point and Port Williams. In many cases this was due to the abundance and diversity of crangonid (especially Crangon alaskensis), hippolytid (especially Eualus sp. and Hippolyte clarki), and pandalid (especially Pandalus danae) shrimps and gammarid amphipods at these two sites. The two new sites located at the eastern end of the strait, Alexander's Beach and West Beach, had epibenthic macroinvertebrate catches similar to Dungeness Spit and Twin Rivers except that gammarid amphipods (especially Atylus tridens) were more abundant. Over the four quarters, catches were lowest and least diverse in winter and generally highest in October; the high autumn catches, however, may be an artifact of the nighttime collections.

Neritic macroinvertebrates captured incidentally by townet indicated fewer distinct trends and a patchier distribution than the epibenthic macroinvertebrates. Mysids (specifically Archaeomysis grebnitzki and Neomysis rayi) were the major cause of the high fluctuations in abundance and standing crop, occurring abundantly at all Strait of Juan de Fuca sites at one time or another and during all seasons except summer. They were not, however, significantly abundant in the catches from the two sites at the eastern end of the strait. In several instances there was a slight increase in the contribution by mysids to the diet spectra of several fish during periods of high mysid abundance, but there were also several instances where no such relationship was evident.

SECTION 3

MATERIALS AND METHODS

3.1 STUDY SITES AND SAMPLING FREQUENCY

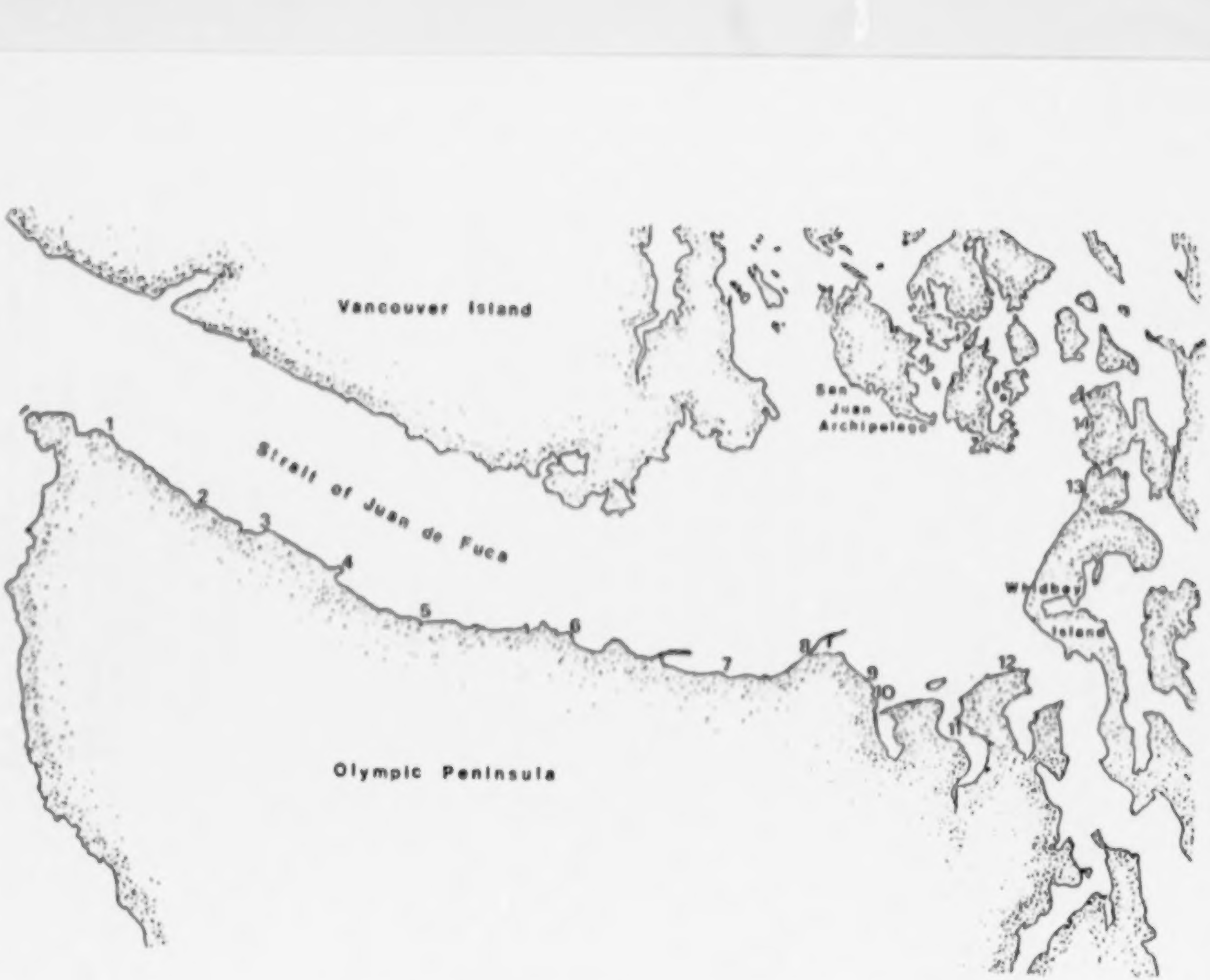
A major consideration in determining sampling sites and sampling design was the desire to make the results of the nearshore fish studies of the MESA Puget Sound Project comparable to data generated during the DOE Northern Puget Sound Biological Baseline Study (Miller et al. 1977), thus facilitating between-area comparisons. Further considerations used to determine sampling sites were: (1) The desire to sample throughout the Strait of Juan de Fuca and Whidbey and Fidalgo Islands; (2) sites had to be accessible to both the land-based beach-seine operation and the ship-based townet operation; (3) sites were chosen to reflect the variety of habitats encountered in the Strait of Juan de Fuca.

Six beach-seine sites and seven townet sites were established along the Strait of Juan de Fuca in 1976. An additional beach-seine and townet site was established on Whidbey Island and on Fidalgo Island in 1977, and seven tidepool sites were established along the Strait of Juan de Fuca in 1977. Collections on Whidbey and Fidalgo Islands were made only during the sampling year 1977-78; intertidal collections were made during 1977-78 and 1978-79. The sampling dates are presented in Appendix 6.1. Sampling sites were characterized by habitat and sampled with three methods designed to capture nearshore demersal (beach seine), neritic (townet), and intertidal (tidepool) fishes (Fig. 1, Table 1). Collection periods were quarterly--winter (December, January), spring (May), summer (August), and fall (October).

3.2 SAMPLING TECHNIQUES

3.2.1 Beach Seine

A 37-m (120-ft) beach seine was used to sample demersal fish occurring within 30 m of shore during slack water at low tide. The beach seine consisted of two wings with 3-cm mesh joined to a 0.6-m x 2.4-m x 2.3-m bag with 6-mm mesh (see Miller et al. 1977, for a diagram of the beach seine). A weighted lead line kept the seine on the bottom. Floating sets were made with seven floats attached to the cork line at regular intervals. The net was set 30 m from the stern of a rowed skiff. Polypropylene lines 30 m long and 2 cm diameter were used to retrieve the net. Two-person teams situated 40 m apart hauled the net at about 10 m/min. For the first 20 m of hauling the teams remained 40 m apart; the final 10 m was hauled with the teams 10 m apart. When the net was entirely on the beach, fish and invertebrates were removed, placed in plastic bags, and labeled for later processing. Replicate


Vancouver Island
San Juan Archipelago
Strait of Juan de Fuca
Whidbey Island
Olympic Peninsula
1
2
3
4
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10
11
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13
14

Fig. 1. Location map of sampling sites.

Table 1. Characterization of study sites along the Strait of Juan de Fuca. BS = beach seine, TN = townet, TP = tidepool.

Site		Habitat	Sampling Method
1	Neah Bay	Moderate gradient, high energy, direct exposure, boulder beach, abundant algae	TP
2	Kydaka Beach	Moderate gradient, high energy, direct exposure, sand substrate, no algae, little detritus	BS, TN
3	Slip Point	Moderate gradient, high energy, direct exposure, rock substrate, abundant algae	TP
4	Pillar Point	Moderate gradient, moderate energy, moderate exposure, rocky kelp bed with adjacent sandflats	TN
5	Twin Rivers	Low gradient, moderate energy, moderate exposure, sand and cobble beach, abundant algae and kelp	BS, TN, TP
6	Observatory Point	High gradient, high energy, direct exposure, rock substrate, abundant algae	TP
7	Morse Creek	Low gradient, moderate energy, moderate exposure, sand and cobble beach, abundant algae and kelp	BS, TN, TP
8	Dungeness Spit	High gradient, high energy, high exposure, sand and gravel beach, no algae, little detritus	BS, TN
9	Jamestown	Low gradient, low exposure, low energy, mudflat with extensive eelgrass beds	BS, TN
10	Port Williams	Low gradient, low exposure, low energy, mudflat with extensive eelgrass beds	BS, TN
11	Beckett Point	Moderate gradient, low exposure, low energy, sand and gravel beach, abundant algae and eelgrass	BS, TN
12	North Beach	Low gradient, low energy, low exposure, sand and cobble beach, some algae	TP
13	West Beach	Moderate gradient, high energy, direct exposure, sand-gravel substrate, little algae	BS, TN
14	Alexander's Beach	Low gradient, low energy, low exposure, sand substrate, little algae	BS, TN

hauls were made at each site except when weather conditions made that impossible. Care was taken so that the area swept by one set was not included in the replicate. Time between sets was at least 30 minutes. At sites where the depth of water was less than 3 m, only sinking sets were made. Where water depth exceeded 3 m (two sites), both floating and sinking sets were made. Beach seining was conducted during slack water at low tide, which involved sampling at night between October and March and during the day between March and October.

3.2.2 Townet

A two-boat surface trawl (townet) was utilized to sample neritic fish occurring in the upper 3.5 m of the water column adjacent to the shoreline. The townet measured 3 m x 6 m (10 x 20 ft), with mesh sizes grading from 76 mm (3 inches) at the brail to 6 mm (1/4 inch) at the bag (see Miller et al. 1977, for a diagram of the townet). The net was towed at 800 rpm (about 3.7 km/hr) between the 12-m (39-ft) FRI research vessel MALKA and a 3.7-m (12-ft) purse seine skiff. At each site, two 10-minute tows were made. One tow was made with the prevailing tidal current along the shoreline and the other tow was made in the opposite direction.

To reduce net avoidance by pelagic species and to optimize sampling of those pelagic species which migrate into shallow water nocturnally, sampling was conducted at night. We also sought to sample during periods of minimal tidal currents and moonlight to reduce sampling variation, but this was not always possible.

The net was towed as close to the shoreline as depth, kelp growth, and flotsam would allow. The net dragged bottom in 5 m (15 ft) of water.

Seldom were we able to follow a consistent transect over the same depth, distance from shore, and length at the townet sites; conditions during the collection periods varied because of tide, flotsam, weather, etc. However, the towing setup proved to be quite maneuverable, allowing us to work along the shoreline rather easily. Townet sampling was generally conducted within one week of beach seine collections.

3.2.3 Intertidal

Two types of intertidal habitat were sampled during low tide: Tidepools and the area beneath large rocks. Both types of habitat were encountered at most intertidal sites. The sites were categorized as rocky headlands (Observatory Point, Slip Point, Neah Bay) and cobble beaches (North Beach, Morse Creek, Twin Rivers), according to their geomorphology.

Tidepools were randomly selected at various heights to ensure sampling over the entire vertical range of the fish. Each tidepool was partly drained to concentrate fish into a small area; a small amount of quinaldine (10% solution in ethyl alcohol) was added to narcotize the fish, facilitating the collection of secretive and elusive species. Rocks were also randomly selected over the vertical range of the fish. The rocks were rolled and the fish beneath them were captured by hand. Fish were preserved in 10% buffered formalin immediately after capture.

3.2.4 Macroinvertebrate Cataloguing

Epibenthic macroinvertebrates were collected at the eight beach seine sites and pelagic macroinvertebrates were collected at the nine townet sites during the first two years of the study. The macroinvertebrates were handpicked from the beach seine and townet and placed in 10% buffered formalin, except for large, readily identifiable crabs and asteroids which were measured (or the size estimated) and released at the time of collection. Preserved samples were brought to the laboratory and identified, weighed, and measured. Species were sorted using a dissecting microscope. For species occurring in numbers greater than 100, subsamples of 50 individuals were weighed and measured, the remainder of the sample was counted and a total weight taken.

Weights were taken to the nearest 0.01 g and lengths were measured to the nearest millimeter. Carapace lengths, eye to posterior edge of carapace, were taken on the shrimp. In the laboratory, crabs were measured at their widest point (carapace width). The remainder of the invertebrates were not measured.

Species identifications were made using a variety of dichotomous keys, illustrated references, descriptions, and an existing reference collection of verified species. The principal references used for taxonomic identification were Banner (1947, 1948, 1950), Barnard (1969), Barnes (1974), Johnson and Snook (1955), Kozloff (1974), Ricketts and Calvin (1968), Schultz (1969), Smith and Carlton (1975), and Staude et al. (1977). A reference collection was organized and maintained for the purpose of comparing prey organisms to verified specimens. Amphipods were identified by Craig Staude at the Friday Harbor Laboratories.

3.3 COLLECTION INFORMATION

The following data were recorded for all sampling methods: Location, date, time, tide stage and height, weather conditions (air temperature, wind speed and direction, visibility, precipitation, and cloud cover), sea surface temperature, salinity and dissolved oxygen, sea state and color, bottom depth, area sampled (beach seine), volume sampled (townet), distance fished, sampling duration, compass heading, light intensity, and current direction and velocity. All information was recorded on computer data forms.

Water samples were obtained for salinity and dissolved oxygen measurements. For beach seine samples, salinity was determined by the potentiometric method and dissolved oxygen by Winkler titration. During townet collections, salinity was measured with a Beckman salinity-temperature probe, and dissolved oxygen was determined by Winkler titration.

3.4 BIOLOGICAL INFORMATION

Catches from the beach seine and townet were bagged, labeled, and placed on ice until processing. Fish retained for stomach analysis were separated from the catch and preserved in 10% formalin immediately after collection.

Generally, catches were taken in their entirety. It became necessary to subsample when the catch of one or more species was too large to permit proper handling within the available time. The less abundant species were sorted from the catch and saved. The abundant species were thoroughly mixed and a known volume greater than or equal to 10% of the sample was removed and saved. The volume of the remaining sample was measured and the fish were discarded.

3.5 PROCESSING THE CATCHES

Fish samples were sorted to species and individuals were counted, measured (total length), and weighed (to the nearest 0.1 g wet weight). Where possible the following information was taken for an individual: Sex, life history stage, external diseases, parasites, and other abnormalities. When the number of individuals of a species in a sample exceeded 100, 50 or more individuals were weighed and measured; the remaining fish were counted and an aggregate weight was taken. All information was recorded on computer data forms. Hart (1973) was used as a reference for identification of the fishes.

Fish to be used for stomach analysis were dissected; the stomach was removed, tagged, and preserved in 10% formalin. In those fish without well-defined stomachs, the first one-third of the intestine was removed and preserved.

3.6 STOMACH ANALYSES

Whole fish specimens or intact stomach samples of economically important fishes were examined according to a systematic, standard procedure (Terry 1977) which identifies the numerical and gravimetric composition of prey organisms, the stage of digestion of the contents, and the degree of stomach fullness. In the laboratory, the stomach samples were removed from the preservative, or from the preserved whole fish, and soaked in cold water for at least two or three hours before examination. The stomach was then identified according to information on the label and then processed. Processing involved taking a total (damp) weight (to nearest 0.01 g), removing the contents from the stomach and weighing each taxonomic category including unidentifiable material. Subjective numerical evaluations of the stomach condition or degree fullness--scaled from 1 (empty) to 7 (distended)--and stage of digestion--scaled from 1 (all digested) to 5 (no digestion)--were made at this time. The stomach contents were then sorted and identified as far as was practical, the sorted organisms were counted, and a total (damp) weight of each taxon was obtained (to nearest 0.001 g). If a sorted taxon was represented by too many individuals to count, the number was estimated using a random grid-counting procedure.

3.7 POSSIBLE SOURCES OF ERROR

A major source of sampling error was gear selectivity. Each gear type possessed its own selectivity which must be taken into account when comparing results of different gear types. Sample variation also resulted from bottom conditions, weather conditions, light intensity (diurnal-nocturnal), sea conditions, bioluminescence, turbidity, and sampling duration.

Density and standing crop estimates for both beach seine and townet were biased because we assumed 100% gear efficiency (e.g., all fish occurring in the 11,500-m^3 section sampled by the townet were assumed captured). The large-mesh wings of the townet and beach seine were not as effective in retaining larvae and small juveniles as the bag, so that quantitative results concerning small fish were likely to be underestimates. Also, certain fast-swimming and fast-reacting species probably were able to avoid the sampling gear.

The topography of the substrate affected the performance of the beach seine. Smooth substrates were swept more efficiently than uneven substrates. Furthermore, large quantities of algae or eelgrass reduced sampling efficiency.

Sampling at Jamestown was discontinued after the first year of the study because of insufficient water depth on zero or minus tides. Port Williams, east of Jamestown near the entrance to Sequim Bay, was added to the sampling plan.

Species identifications may constitute a source of error. All adult specimens and the vast majority of juvenile specimens were readily identifiable. Some species of larval fish and macroinvertebrates presented identification problems, so in some instances species richness (number of species) may have been underestimated.

Sample bias was also introduced by the crew during the picking of the net. Transparent larvae and small fish may have been overlooked, particularly when sampling was conducted at night in inclement weather.

Beach seining was conducted on the lowest tides of the sampling period. During October through January, sampling occurred at night whereas in May through August it occurred during the day. Comparison of these two periods must take into consideration potential diel changes in the fish fauna.

Bias also occurred in sampling the macroinvertebrates collected with the fish. The more fish and algae present in the net, the less efficient the invertebrate sampling effort because of the difficulty in finding invertebrates among the algae and also because of time constraints involved in setting and retrieving the net.

3.8 DEFINITIONS AND STATISTICS

3.8.1 Definitions

Occurrence or % occurrence means the number or percentage of discrete samples (e.g., stomachs or hauls) in which a species was present. Abundance means the total number of individual organisms caught. Biomass means the total wet weight of the organisms caught.

Density means the ratio of the total number of organisms to the sampling area (beach seine) or volume (townet and tidepool collections) in a discrete sample and is expressed as number/m^2 or number/m^3. In the special case of tidepool collections made beneath single rocks, it is expressed as number/rock.

Standing crop is the ratio of the total biomass of organisms to the sampling area (beach seine) or volume (townet and tidepool collections) in a discrete sample and is expressed as grams/m^2 or grams/m^3. In the special case of tidepool collections made beneath single rocks, it is expressed as grams/rock.

Species richness is the number of species present in a sample or group of samples.

3.8.2 Statistics

3.8.2.1 IRI trophic diagrams. A modification of Pinkas et al. (1971), "Index of Relative Importance" (IRI) was used to rank the importance of prey organisms. The IRI values for prey taxa are displayed both graphically and in tabular form where justified by sample size (n > 25). The three-axis IRI graphs illustrate frequency of occurrence (the proportion of stomachs containing a specific prey organism) plotted sequentially on the horizontal axis, and percentage of total abundance and percentage of total biomass plotted above and below the horizontal axis, respectively (Fig. 2). All prey groups, including those assigned to a broad taxonomic level (family, order, class) because of inability to assign a more specific identification, have been arranged from left to right by decreasing frequency of occurrence. Prey taxa in differing stages of digestion (e.g., partly digested shrimp, "Natantia-unidentified," as opposed to family, "Pandalidae," or species, "*Pandalus borealis*") are graphed separately.

The IRI value was computed as follows:

$$\text{IRI} = \%\ \text{Frequency of occurrence}_i \left[\%\ \text{Numerical composition}_i + \%\ \text{Gravimetric composition}_i \right]$$

and is equivalent to the area encompassed by the bar for each prey category i composing the IRI diagrams. In order to compare the IRI values between prey spectra with different sample sizes, the overall importance of general prey taxa (e.g., all shrimp, including "unidentified Natantia" and those identified to family and species, added together) has been discussed as a percentage of the total combined IRI (areas) of the different prey taxa. Table 2 illustrates an example of the IRI values and percentages of total IRI generated from the data diagrammed in Fig. 2. The advantage of the IRI value is that the more representative prey are not dominated by numerically rare but high biomass prey (e.g., prey$_8$, Fig. 2), by infrequently occurring but abundant or high biomass (when eaten) taxa, nor by numerically abundant or frequently occurring taxa which contribute little in the way of biomass (e.g., prey$_1$, Fig. 2).

3.8.2.2 Trophic diversity and dietary overlap. Four quantitative indices of the composition and overlap of predator diets were used to describe trophic diversity:

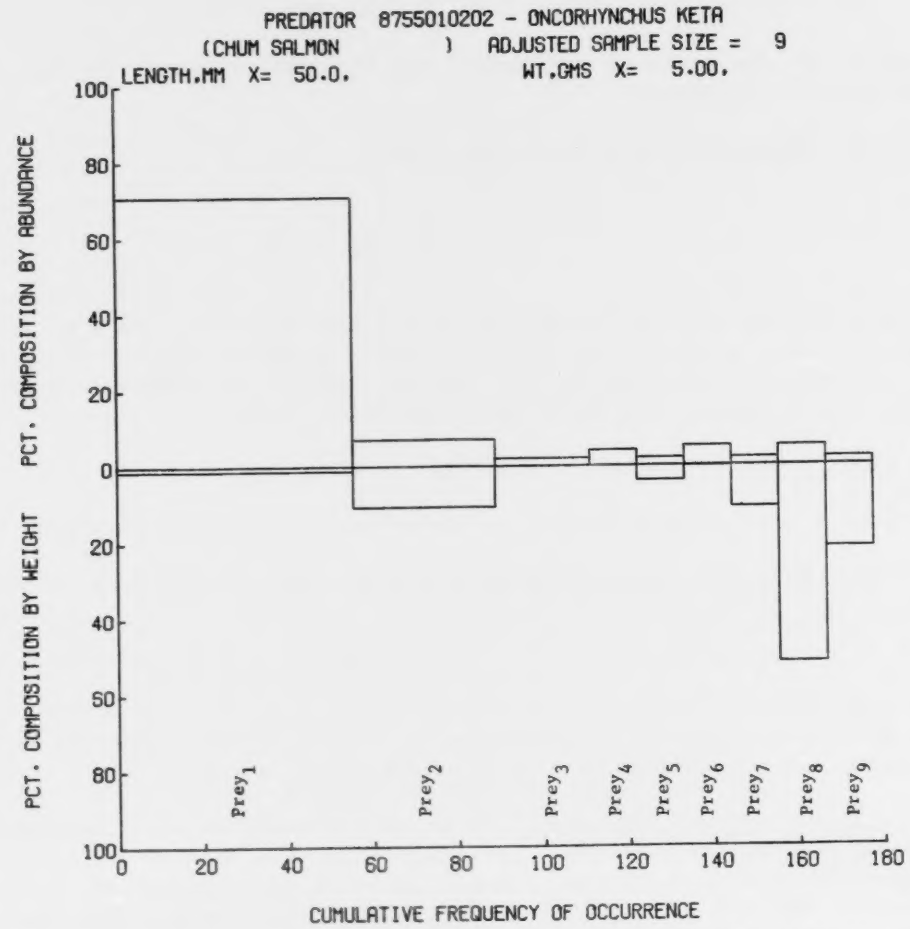

Fig. 2. Example of index of relative importance (I.R.I.) diagram.

Table 2. IRI table.

PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
Prey_1	55.56	70.71	1.18	3993.5	68.45
Prey_2	33.33	7.07	10.68	591.6	10.14
Prey_3	22.22	2.02	.03	45.0	.78
Prey_4	11.11	4.04	.00	44.9	.77
Prey_5	11.11	2.02	3.84	65.1	1.12
Prey_6	11.11	5.05	.12	57.4	.98
Prey_7	11.11	2.02	10.90	143.5	2.46
Prey_8	11.11	5.05	51.72	630.8	10.81
Prey_9	11.11	2.02	21.54	261.8	4.49

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.51	.34		.49
SHANNON-WEINER DIVERSITY	1.70	1.93		1.64
EVENNESS INDEX	.54	.61		.52

(1) Percent dominance index: $\% \text{ Dominance} = \Sigma(p_i)^2$

where p_i is the ratio of the number (or biomass) of prey_i to the total prey abundance (or biomass).

(2) Shannon-Wiener diversity index:

$$H' = -\sum_{i=1}^{s} (p_i \, Ln_2 p_i)$$

where p_i is the same as in the percent dominance index and s is the total number of species. H′ incorporates both the number of prey taxa present and the evenness of the distribution (either numbers or biomass) among these taxa, and is relatively insensitive to sample size.

(3) Evenness index: $e = H'/Lns$

where H′ is the Shannon-Wiener index and s is the total number of species.

(4) Dietary overlap: Sanders (1960) Index of Affinity (similarity),

$$\%S = \Sigma \min p_i$$

was used as an index of diet overlap, where p_i is the percentage of the total IRI which each prey taxon constituted. Silver (1975) suggested that 80% similarity was a reasonable significance level.

3.8.2.3 Linear regression. The relationship between abundance and biomass and the oceanographic parameters measured at each site was investigated with a stepwise linear regression model and analysis of variance. Abundance and biomass values were transformed with logarithms (base 10) to normalize the variance (Zar 1974).

3.9 DISPOSITION OF DATA

All data were initially recorded on computer sheets in format required by MESA specification. Codes utilized in data recording were developed by the National Oceanographic Data Center (NODC). The data were checked for errors, keypunched on 80-column IBM cards, and verified. All data cards were systematically organized, transferred onto magnetic tape, and submitted to NODC quarterly.

3.10 SPECIES NOMENCLATURE

Unless otherwise noted, all names of fishes, both scientific and common, are based on the American Fisheries Society list (1970). The only change that has appeared subsequent to that list is for the bay pipefish, which has been changed from *Syngnathus griseolineatus* to *S. leptorhynchus*, according to Miller and Lea (1972).

SECTION 4

RESULTS AND DISCUSSION

4.1 OCEANOGRAPHIC CONDITIONS

Temperature, salinity, and dissolved oxygen data are presented in Appendix 6.2 for beach-seine, townet, and tidepool collections.

4.1.1 Beach Seine

The relationship between abundance and biomass and the oceanographic parameters measured at each site was investigated with stepwise linear regression and analysis of variance. Log abundance and log biomass were poorly predicted by the oceanographic parameters measured; only 10 out of the possible 48 parameters (20.8%) were significant (Table 3). The conclusion is that while some of the oceanographic parameters may be locally important in determining the abundance or biomass of nearshore fish (e.g., temperature at Dungeness Spit), there is no predictable relationship across all sites.

4.1.2 Townet

A regression analysis of variance was also performed on abundance and biomass measurements from townet catches (Table 4). Log abundance was poorly predicted by the oceanographic parameters measured; log biomass was poorly predicted by salinity and dissolved oxygen but was predicted fairly well by temperature. Temperature was significant at six of the seven sites and was always positively related to biomass--i.e., an increase in temperature was correlated with an increase in biomass. The amount of variance in biomass explained by the regression (r^2) ranged from 17% to 48% (mean = 36%).

4.2 NEARSHORE FISH SPECIES COMPOSITION

A total of 94 species was collected from May 1976 to June 1979 during sampling operations (Tables 5, 6). A decrease in the number of species collected by beach seine and townet was observed as the study progressed. This was largely a result of absence of rare species in the catches during the second and third years of sampling. Some species--e.g., rock greenling, Pacific sandfish, plainfin midshipman, and kelp perch--were represented by fewer than five specimens in a particular year and none in others. The presence or absence of rare species in the catches is stoichastic and not regarded as significant.

Table 3. Summary of stepwise multiple linear regression of log abundance and log weight against temperature, salinity, and dissolved oxygen for beach seine catches. NS = not significant; the significance level is given where appropriate; the coefficient of determination (r^2) is given in parentheses. The equations are in the form

$$\hat{Y}_i = a+bX_i \pm s_{y \cdot x}$$

where $s_{y \cdot x}$ = standard error of the regression.

Site	Log abundance			Log weight		
	Temp.	Sal.	DO	Temp.	Sal.	DO
Kydaka Beach	NS	NS	NS	NS	NS	NS
Twin Rivers	NS	NS	NS	NS	NS	NS
Morse Creek	NS	NS	NS	NS	NS	NS
Dungeness Spit sinking[1]	0.012 (0.33)	NS	NS	0.015 (0.14)	NS	0.049 (0.20)
Dungeness Spit floating[2]	0.008 (0.38)	NS	NS	NS	NS	NS
Port Williams[3]	NS	0.023 (0.30)	0.004 (0.33)	NS	NS	NS
Beckett Point sinking[4]	NS	NS	0.007 (0.50)	NS	NS	NS
Beckett Point floating[5]	NS	0.030 (0.33)	NS	NS	0.002 (0.50)	0.043 (0.16)

[1] $\text{Log(nos.)} = -0.137 + 0.194\ \text{(temp)} \pm 0.5273$
$\text{Log (wt.)} = 1.603 + 0.238\ \text{(temp)} - 0.165\ \text{(DO)} \pm 0.6197$

[2] $\text{Log (nos.)} = -2.393 + 0.407\ \text{(temp)} \pm 0.7918$

[3] $\text{Log (nos.)} = 9.129 - 0.463\ \text{(DO)} - 0.936\ \text{(sal)} \pm 0.3715$

[4] $\text{Log (nos.)} = 3.737 - 0.119\ \text{(DO)} \pm 0.5109$

[5] $\text{Log (nos.)} = -12.508 + 0.479\ \text{(sal)} \pm 0.5254$
$\text{Log (wt.)} = -19.647 + 0.772\ \text{(sal)} - 0.864\ \text{(DO)} \pm 0.5079$

Table 4. Summary of stepwise multiple linear regression of log abundance and log weight against temperature, salinity, and dissolved oxygen for townet catches. NS = not significant; the significance level is given where appropriate; the coefficient of determination (r^2) is given in parentheses. The equations are in the form

$$\hat{Y}_i = a + bX_i \pm s_{y \cdot x}$$

where $s_{y \cdot x}$ = standard error of the regression.

	Log abundance			Log biomass		
Site	Temp.	Sal.	DO	Temp.	Sal.	DO
Kydaka Beach[1]	NS	NS	NS	0.002 (0.40)	NS	NS
Pillar Point[2]	0.009 (0.30)	NS	NS	<0.001 (0.48)	NS	NS
Twin Rivers[3]	NS	<0.001 (0.48)	NS	0.015 (0.17)	0.002 (0.36)	NS
Morse Creek[4]	NS	NS	NS	0.001 (0.33)	NS	<0.001 (0.27)
Dungeness Spit[5]	0.046 (0.19)	NS	NS	NS	NS	NS
Jamestown-Port Williams	0.001 (0.13)	<0.001 (0.14)	0.001 (0.34)	<0.001 (0.46)	0.022 (0.13)	NS
Beckett Point[7]	NS	0.001 (0.44)	NS	0.006 (0.32)	NS	NS

[1] Log (wt) = −0.711 + 0.243 (temp °C) ± 0.5454

[2] Log (nos.) = −2.268 + 0.477 (temp) ± 0.8711
Log (wt) = −4.181 + 0.697 (temp) ± 0.8566

[3] Log (nos.) = 37.640 − 1.089 (sal) ± 0.9720
Log (wt) = 22.437 − 0.726 (sal) + 0.347 (temp) ± 0.7667

[4] Log (wt) = 3.542 − 0.725 (DO) + 0.521 (temp) ± 0.8672

[5] Log (nos.) = −1.288 + 0.377 (temp) ± 0.9498

[6] Log (nos.) = −37.657 + 0.541 (temp) + 0.923 (sal) + 0.064 (DO) ± 0.6008
Log (wt) = −13.246 + 0.594 (temp) + 0.315 (sal) ± 0.5762

[7] Log (nos.) = 63.267 − 1.915 (sal) ± 0.8360
Log (wt) = −1.270 + 0.321 (temp) ± 0.9958

Table 5. Number of species collected by each sampling method.

Gear	1976-77	1977-78	1978-79	Total
Beach seine	69	59	60	81
Townet	48	42	34	60
Intertidal	--	24	25	26
Total	76	76	69	94

4.2.1 Dominant Species, Beach Seine

The rank order of the most abundant species summed across all collections at all sites is presented in Table 7. The general consistency of rankings among years suggests that, at least for the abundant species, occupation of a particular habitat is fairly constant from year to year and that quarterly sampling with a beach seine is effective in documenting major trends in the nearshore fish assemblages.

Between-year differences in the rank order abundances were largely a result of the sporadic occurrence of a few large individuals--e.g., spiny dogfish and chinook salmon--which greatly influenced biomass measurements, and schooling species--e.g., Pacific herring, Pacific sand lance, and Pacific tomcod--which because of their mobility were not collected consistently. The presence of the tidepool sculpin in 1977-78 and 1978-79 rankings is a result of substituting Port Williams for the Jamestown site. Tidepool sculpin inhabit a large rock outcrop adjacent to the area sampled with the beach seine at Port Williams; on an ebbing tide the sculpins move off the outcrop and into the area sampled.

Variations in the strength of year classes within a species can affect the rankings, or even presence or absence, in the table. There is some evidence that this is the case for speckled sanddab. During the first two years of the study, only a few speckled sanddab were collected on two beaches (Kydaka Beach, Beckett Point); during the last year of the study, sanddab were collected at every site and were ten times as abundant as in previous years.

A list of the regularly occurring and abundant species by season and by site for each year of the study is presented in Table 8. Beach-seine catches were dominated by juveniles of three species: Pacific staghorn sculpin, English sole, and sand sole. They were present on all beaches during most of the sampling periods. The similarity of substrates among the sampling sites accounts for their widespread occurrence. Sand sole were more abundant on pure sand and coarse sand substrates with little vegetation or detritus (Kydaka Beach, Dungeness Spit), while English sole and Pacific staghorn sculpin were more abundant on mixed sand and mud substrates with more vegetation and detritus. All three species appeared on the beaches in the spring as metamorphosing larvae or as recently metamorphosed juveniles. They remained on the beaches throughout the summer and fall. By winter they had largely disappeared--probably moving into deeper water in response to

Table 6. Nearshore fish species collected by beach seine (BS), townet (TN), and tidepool (TP).

Species	Common name	Gear
Squalus acanthias	spiny dogfish	BS,TN
Raja binoculata	big skate	BS
R. stellulata	starry skate	BS
Hydrolagus colliei	ratfish	BS,TN
Clupea harengus pallasi	Pacific herring	BS,TN
Engraulis mordax	northern anchovy	BS,TN
Oncorhynchus gorbuscha	pink salmon	BS,TN
O. keta	chum salmon	BS,TN
O. kisutch	coho salmon	BS,TN
O. tshawytscha	chinook salmon	BS,TN
Salmo clarki	cutthroat trout	BS
S. gairdneri	rainbow trout	BS
Hypomesus pretiosus	surf smelt	BS,TN
Mallotus villosus	capelin	TN
Spirinchus thaleichthys	longfin smelt	BS,TN
Porichthys notatus	plainfin midshipman	BS
Gobiesox maeandricus	northern clingfish	BS,TN,TP
Gadus macrocephalus	Pacific cod	BS
Microgadus proximus	Pacific tomcod	BS,TN
Theragra chalcogramma	walleye pollock	BS,TN
Aulorhynchus flavidus	tube-snout	BS,TN
Gasterosteus aculeatus	threespine stickleback	BS,TN
Syngnathus leptorhynchus	bay pipefish	BS,TN
Amphistichus rhodoterus	redtail surf perch	BS
Cymatogaster aggregata	shiner perch	BS,TN
Brachyisticus frenatus	kelp perch	BS,TN
Embiotoca lateralis	striped sea perch	BS,TN
Rhacochilus vacca	pile perch	BS,TN
Trichodon trichodon	Pacific sandfish	BS,TN
Anoplarchus purpurescens	high cockscomb	BS,TN,TP
Chirolophus nugator	mosshead warbonnet	TP
Lumpenus sagitta	snake prickleback	BS,TN
Phytichthys chirus	ribbon prickleback	TP
Xiphister atropurpureus	black prickleback	TP
X. mucosus	rock prickleback	TP
Apodichthys flavidus	penpoint gunnel	BS,TN,TP
Pholis laeta	crescent gunnel	BS,TN,TP
P. ornata	saddleback gunnel	BS,TN,TP
Anarrhichthys ocellatus	wolf eel	TN
Ammodytes hexapterus	Pacific sand lance	BS,TN
Sebastes entomelas	widow rockfish	BS,TN
S. flavidus	yellowtail rockfish	BS
S. melanops	black rockfish	TN
Hexagrammos decagrammus	kelp greenling	BS,TN
H. lagocephalus	rock greenling	BS,TP
H. stelleri	whitespotted greenling	BS
Ophiodon elongatus	lingcod	BS,TN
Artedius fenestralis	padded sculpin	BS,TN,TP
A. harringtoni	scalyhead sculpin	BS,TP
A. lateralis	smoothhead sculpin	BS,TP

Table 6. (Contd.)

Species	Common name	Gear
Ascelichthys rhodorus	rosylip sculpin	BS,TN,TP
Blepsias cirrhosus	silverspotted sculpin	BS,TN,TP
Chitonotus pugetensis	roughback sculpin	BS
Clinocottus acuticeps	sharpnose sculpin	BS,TN,TP
C. embryum	calico sculpin	TP
C. globiceps	mosshead sculpin	TP
Enophrys bison	buffalo sculpin	BS,TN,TP
Hemilepidotus hemilepidotus	red Irish lord	BS,TN,TP
Leptocottus armatus	Pacific staghorn sculpin	BS,TN
Myoxocephalus polyacanthocephalus	great sculpin	BS,TN
Nautichthys oculofasciatus	sailfin sculpin	BS,TN
Oligocottus maculosus	tidepool sculpin	BS,TP
O. rimensis	saddleback sculpin	BS,TP
O. snyderi	fluffy sculpin	BS,TP
Radulinus boleoides	darter sculpin	TN
Rhamphocottus richardsoni	grunt sculpin	TN
Scorpaenichthys marmoratus	cabezon	BS
Synchirus gilli	manacled sculpin	BS,TN
Gilbertidia sigalutes	soft sculpin	TN
Psychrolutes paradoxus	tadpole sculpin	BS,TN
Agonopsis emmelane	northern spearnose poacher	BS
Agonus acipenserinus	sturgeon poacher	BS,TN
Bathyagonus nigripinis	blackfin poacher	TN
Occella verrucosa	warty poacher	BS
Odontopyxis trispinosa	pygmy poacher	BS
Pallasina barbata	tubenose poacher	BS,TN
Xeneretmus latifrons	blacktip poacher	BS,TN
Eumicrotremus orbis	Pacific spiny lumpsucker	BS,TN
Liparis callyodon	spotted snailfish	BS,TN
L. cyclopus	ribbon snailfish	BS,TP
L. dennyi	marbled snailfish	BS
L. florae	tidepool snailfish	BS,TN,TP
L. mucosus	slimy snailfish	BS
L. pulchellus	showy snailfish	BS,TN
L. rutteri	ringtail shailfish	BS,TN,TP
Citharichthys stigmaeus	speckled sanddab	BS
C. sordidus	Pacific sanddab	BS
Isopsetta isolepis	butter sole	BS
Lepidopsetta bil ineata	rock sole	BS,TN
Parophrys vetulus	English sole	BS,TN
Platichthys stellatus	starry flounder	BS,TN
Pleuronichthys coenosus	C-O sole	BS
Psettichthys melanostictus	sand sole	BS
Microstomus pacificus	Dover sole	BS

Table 7. Rank order of the most abundant fishes in beach seine collections.

	Occurrence			Abundance			Biomass		
	76/77	77/78	78/79	76/77	77/79	78/79	76/77	77/78	78/79
Pacific staghorn sculpin	1.5	1.5	1	5	4	8	5	2	3
English sole	1.5	1.5	2	8	8	6			7
Sand sole	3	2.5	2.5	7	6	3	8	7	4
Starry flounder	4	5	3.5				2	3	5
Buffalo sculpin	5	6	7						
Striped perch	6	9	10			9	7	9	6
Pacific tomcod	7.5			10	9			10	
Padded sculpin	7.5	2.5	3.5						
Redtail surfperch	10.5	9			10	7	1	6	1
Herring	10.5	9		2			9		
Surf smelt	10.5		10	9		5		5	8
Tubesnout	10.5		10	4	7	4			
Shiner perch		7		3	3	1	4	4	2
Rosylip sculpin				6	5				
Chinook salmon							3		
Spiny dogfish							6		
Sand lance				1	1		10	1	
Tidepool sculpin					2	2		8	9
Silverspotted sculpin			8						
Speckled sanddab			5.5			10			10

Table 8. Regularly occurring and abundant species in beach seine collections by site and by season for each of the study years; F = few (< 10 individuals), C = common (10-25), A = abundant (26-100), AA = very abundant (> 100). Data based upon two seine hauls at each site in each season.

Species	1976-77				1977-78				1978-79			
	SP	SU	F	W	SP	SU	F	W	SP	SU	F	W
KYDAKA BEACH												
Pacific herring		AA				A	F					
Redtail surfperch	F		no collection	F	F		C	no collection	F	F		C
Pacific sand lance		C				AA	F			F		
Pacific staghorn sculpin				F		F	A		F	C		
Speckled sanddab						A			A	AA		C
English sole	A			F	F	C	F		F	F		
Starry flounder	F	C			F	F	F		F	C		
Sand sole	A	A		C	C	A	A		A	AA	A	
TWIN RIVERS												
Redtail surfperch	F	A	AA	A	F	AA	C	C	A	AA	AA	C
Striped seaperch		AA	F			C		C	F	F	F	F
Penpoint gunnel		A			F	A	F		F	A	F	
Crescent gunnel	F	A				F			F	F		
Saddleback gunnel		A				C				F	F	
Padded sculpin		F	A	C	F	A	A	C	F		F	F
Rosylip sculpin	F	AA	F	F	F	AA	AA		F	A	F	
Silverspotted sculpin	F	AA	A	C	F	C	F	C		A	C	F
Buffalo sculpin	F	F	A	F					F	F		F
Pacific staghorn sculpin		F	C	A	F	F	F	F	F	F	F	F
Tubenose poacher		A	F			F	F	F		C	C	
English sole	F	AA	A	A	F	A	F	C	A	A	A	
Starry flounder		F	F	C	F	F	F	F	C	F	F	F
Sand sole	F	C	C	A	C	A	AA	A	F	A	AA	F

Table 8 . (Con'd.)

Species	1976-77				1977-78				1978-79			
	SP	SU	F	W	SP	SU	F	W	SP	SU	F	W
MORSE CREEK												
Surf smelt	F	AA				C	C		A	F	AA	no collection
Pacific tomcod		C	F			F	A			A		
Tube-snout		F	F	F		A	F	F		AA	F	
Striped seaperch	F	F		F	F	F		F		F	C	
Silverspotted sculpin	F	F	F		F	F	C			A	F	
Pacific staghorn sculpin		F	F	F	F	C	F	F	F	F	C	
English sole	F	A	F	F	F	A	F	F	C	A	F	
Starry flounder	F		F	F	F	F	F			F	F	
Sand sole		C	F	F	F	A	AA	A	F	A	A	
DUNGENESS SPIT												
Spiny dogfish	F	C	F				no collection				F	
Pacific herring	C	AA	F			F		F		F		
Surf smelt		F	F						AA		F	
Pacific tomcod		A	F					AA		C		
Pacific sand lance		AA	F					F				
Pacific staghorn sculpin	F	C	C	F	F	F			F	A	C	F
English sole	F	A		F		C		F	C	F		F
Sand sole		AA	A	C	F	A		F	A	AA	AA	A

Table 8 . (Contd.)

	JAMESTOWN - PORT WILLIAMS											
Species	1976-77				1977-78				1978-79			
	SP	SU	F	W	SP	SU	F	W	SP	SU	F	W
Shiner perch			no collection	no collection	F	F	AA	A		F	F	F
Padded sculpin					F	F	F	F		F	A	
Sharpnose sculpin		F				C	AA	F	F		A	C
Pacific staghorn sculpin	F	A			F	AA	AA	F	A	A	A	C
Tidepool sculpin					F	AA	AA	AA	A	AA	AA	A
English sole	A	A			F	AA	F	A	A	A	A	C
Starry flounder		C			F	C	A	F	F	F	C	F
	BECKETT POINT											
Pacific tomcod	F	F	A	AA		F	A	A		A	AA	
Tube-snout	F		C	AA			A	AA		C	F	AA
Shiner perch		AA	AA	AA		AA	AA	AA		AA	AA	A
Striped seaperch	F	C	F	F	F	F	A	C	F	F	A	
Padded sculpin		F	A	F		F	A	F	F	C	A	F
Roughback sculpin	F			A	F		F	F	F	F	F	F
Buffalo sculpin	F	F	C	F	F	F	A	C	C	F	A	A
Pacific staghorn sculpin	AA	A	A	A	C	A	A	A	A	A	AA	A
Great sculpin	F	A	C	F	F	F	F	F	C	F	F	F
English sole	A	C		A	C	F	C	A	C		AA	A
Starry flounder	F	F	F	F	F	F	F	F		F	F	F

lowered temperatures and reduced food availability in the nearshore environment.

The list of predominant species collected by beach seine in northern Puget Sound (Miller et al. 1977) is quite similar to the list compiled for the Strait of Juan de Fuca. Noticeably absent from northern Puget Sound collections, but abundant in the strait collections, were sand sole and redtail surfperch. Small schooling species (e.g., Pacific herring, Pacific sand lance, Pacific tomcod, surf smelt, shiner perch, and tube-snout) were ranked generally higher in northern Puget Sound collections than in Strait of Juan de Fuca collections.

4.2.2 Dominant Species, Townet

Pacific herring, and to a lesser extent longfin smelt, predominated in townet catches (Tables 9, 10). Pacific herring accounted for 76% of all fish by number and 75% of the total biomass of fish caught. Longfin smelt accounted for 16% of all fish by number and 11% of the total biomass. The remaining 58 species contributed only 8% to the number of fish caught and 14% of the total biomass. Caution is therefore recommended in attributing significance to variations in the rank order of species beyond Pacific herring and longfin smelt.

Pacific herring were most abundant during the spring and summer when they occurred as larvae and juveniles, respectively. Less than one percent of all herring were caught in the fall and winter, reflecting their movement out of the nearshore waters. No adult herring were captured during the study, while juveniles occurred at all sites and in the majority of collections (88%). The size of catches at a particular site varied between years and no consistent pattern could be discerned. This is most likely a result of the schooling nature of Pacific herring and the fact that the schools are patchily distributed. Thus, while it is clear from the data that Pacific herring are most abundant during spring and summer, it is difficult to separate out variations in year class strength and preference for a particular area from the bias introduced by sampling patchily distributed fishes.

More than 99% of all longfin smelt collected were captured at Pillar Point and Twin Rivers. Summer and fall were the periods of greatest abundance. Most of the longfin smelt were young-of-the-year but a few adults (some ripe) were also captured. The restricted distribution of young-of-the-year smelt probably reflects the proximity of suitable spawning grounds--the Pysht River and Twin Rivers. Curiously, few longfin smelt were captured during the 1978-79 sampling year. Two possible reasons are offered: (1) There simply was a poor year class in 1978-79, and (2) sampling was too limited to catch the patchily distributed longfin smelt.

Although numerically not abundant, catches of juvenile salmonids deserve some mention because of their economic importance. A total of 117 juvenile salmonids from four species (49 chum, 33 chinook, 32 pink, 3 coho) was collected; 55% came from collections at Beckett Point and 27% from Jamestown-Port Williams. Eighty-nine percent of the salmonids occurred in summer collections.

Table 9. Rank order of the most abundant fishes in townet collections.

	Occurrence			Abundance			Biomass		
	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79
Pacific herring	1	1	1	1	1	1	1	1	1
Surf smelt	2	5	3	5	4	3	9	7	
Tadpole sculpin	3	3.5	5	7	9	5			
Crescent gunnel	4	11	5.5		10				
Pacific sand lance	5.5	2	2	8	3	2		5	
Walleye pollock	5.5			4	8				
Longfin smelt	7			2	2		4	2	
Tubesnout	8	5.5	5.5	9		6		6	5
English sole	9			10					
Shiner perch	11.5	5.5		3	5	8.5	2	4	
Pink salmon	11.5								
Northern anchovy	11.5	7.5	4		7	4			
Manacled sculpin	11.5	7.5							
Pacific tomcod		3.5		6	6		7	10.5	8
Spiny dogfish		11				9.5	3	3	2
Starry flounder							5		4
Coho salmon							6		
Pile perch							8		
Striped perch							10		
Chinook salmon		11	9		9.5			8	10
Pacific staghorn sculpin								9	
Wolf eel								10.5	
Kelp greenling									3
Threespine stickleback		9							
Sailfin sculpin			9						
Widow rockfish			6.5			7			7
Chum salmon			9			8.5			6
Bay pipefish			6.5						
Pacific sandfish									9

Table 10. Regularly occurring and abundant species in townet collections by site and by season for each of the study years; F = few (< 10), C = common (10-25), A = abundant (26-100), AA = very abundant (> 100). Data based upon two townet hauls at each site in each season.

Species	1976-77				1977-78				1978-79			
	SP	SU	F	W	SP	SU	F	W	SP	SU	F	W
KYDAKA BEACH												
Pacific herring	A	C	C	F	AA	AA	F		AA	A	F	
Surf smelt	F			F	AA						F	
Longfin smelt				AA								
Pacific sand lance	C		F		AA	F			C		F	
PILLAR POINT												
Pacific herring	AA	A	AA	F	AA	AA	F		AA	AA	F	
Surf smelt	F	F	F	F	C		F		C		F	
Longfin smelt		AA		A		AA						
TWIN RIVERS												
Pacific herring	AA	AA	A	F	AA	A	A	no collection	AA	A		
Surf smelt	A	AA	A	F	AA				AA			
Longfin smelt	C	AA	AA	AA		A	AA					
Pacific sand lance	A				AA				AA			
MORSE CREEK												
Pacific herring	AA	C	AA		AA	AA	A	F	AA	A		
Pacific sand lance	A		F		AA	AA	F		A		F	

Table 10. (Contd.)

Species	1976-77				1977-78				1978-79			
	SP	SU	F	W	SP	SU	F	W	SP	SU	F	W
DUNGENESS SPIT												
Pacific herring	AA	AA	C		AA	AA	AA	F	AA		A	
Surf smelt	A	F	F					F	AA			
Pacific sand lance	A	F	F		AA	C	C	F	AA	F		
JAMESTOWN - PORT WILLIAMS												
Pacific herring	A	A	F	F	AA	AA	A	C	AA	C	C	
Pacific sand lance	C				AA				A			
BECKETT POINT												
Pacific herring	AA	AA	F	F	AA	F	AA	F	AA	F		
Shiner perch	F	AA	AA			F	F	A	C	F		
Pacific sand lance	F				C				AA	F		

As in the Strait of Juan de Fuca, Pacific herring ranked first in occurrence, abundance, and biomass in northern Puget Sound (Miller et al. 1977). Longfin smelt were more abundant in the strait, while threespine stickleback were more abundant in northern Puget Sound.

4.2.3 Dominant Species, Intertidal

Tidepool and beneath-rock collections were dominated by tidepool sculpin, northern clingfish, and high cockscomb (Tables 11, 12). They occurred at all sites but composed a greater proportion of the collections on the cobble beaches (Twin Rivers, Morse Creek, North Beach) than on the rocky headlands (Neah Bay, Slip Point, Observatory Point); this was a result of the greater number of species found on the rocky headlands. Tidepool sculpin occurred almost exclusively in tidepools, while northern clingfish and high cockscomb occurred beneath rocks both in and out of tidepools.

The year-to-year consistency in occurrence, abundance, and biomass rankings (Table 11) is not altogether surprising. The assemblage of intertidal fishes consists of 16 species, a rather limited number compared to nearshore areas accessible to a beach seine. There are, therefore, a limited number of combinations of the 10 most abundant species. Additionally, intertidal fish are microhabitat specialists, so their numbers are probably limited by the amount of their proper habitat which varies little from year to year. Finally, ranking fish by occurrence, abundance, or biomass obscures the magnitude of the differences between them, which in some years may be great and in others small, but the overall ranking remains the same.

4.3 NEARSHORE FISH SPECIES RICHNESS

4.3.1 Beach Seine

A yearly summary of the species richness (number of species) caught at each site is presented in Table 13 and Appendix 6.3. Species richness generally increased from west to east in the Strait of Juan de Fuca, including sites at Whidbey and Fidalgo Islands. Exposed sites yielded fewer species than nearby, more protected sites. For example, Twin Rivers yielded more species than Kydaka Beach and Morse Creek yielded more species than Dungeness Spit. The causes of this trend are likely the interrelationships between exposure and habitat complexity. Homogeneous, low-relief beaches (Kydaka Beach, Dungeness Spit) offer neither a wide variety of habitats necessary to attract a wide array of species, nor abundant refuges from turbulence generated by storms; consequently, few species coexist there.

Between-year variations in the number of species captured were low (less than 25%), with the exception of Dungeness Spit in 1977-78. Low between-year variations are surprising if one considers that while some species are present at a particular site every year (i.e., the predominant species), rare species tend to occur erratically. This is reflected in the total number of species captured at a site over all three years which was always greater than the number of species collected in any one year.

Table 11. Rank order of the most abundant fishes in intertidal collections.

Species	Occurrence		Abundance		Biomass	
	77/78	78/79	77/78	78/79	77/78	78/79
Tidepool sculpin	1	1	1	1	1	2
Northern clingfish	2	3	3	5	5	6
High cockscomb	3	2	2	2	4	4
Black prickleback	4	5	4	4	2	3
Rosylip sculpin	5	10	6		6	10
Mosshead sculpin	6	4	5	3	7	5
Fluffy sculpin	7	8	7	8	8	9
Rock prickleback	8	6	9	6	3	1
Calico sculpin	10	7	8	7	9	
Smoothhead sculpin	10	9		9	10	8
Tidepool snailfish	10					
Sharpnose sculpin			10			
Ribbon prickleback				10		7

Table 12. Regularly occurring and abundant species in intertidal collections by site and by season for each of the study years. F=few (<10 individuals), C=common (10-25), A=abundant (26-100). Data based upon varying amounts of effort but regarded as typical for each session at each site.

	1977-78				1978-79			
Species	Sp	Su	F	W	Sp	Su	F	W
NEAH BAY								
Northern clingfish	C	F			C	C		
High cockscomb	C	C			C	C		
Black prickleback	F	F			F	F		
Rock prickleback	F	F			F			
Tidepool sculpin	C	C			A	C		
Fluffy sculpin	A	C			C	C		
SLIP POINT								
Northern clingfish	C	C	F	C	F	F	C	F
High cockscomb	A	A	A	A	A	A	A	A
Black prickleback	A	C	C	F	C	F	F	
Rock prickleback	C	F	F		F	F	F	F
Smoothhead sculpin	F	F			F	F		F
Sharpnose sculpin	C	C	C	C	C	C	F	C
Mosshead sculpin	C	C	C	C	C	C	C	C
Tidepool sculpin	A	A	A	A	A	A	A	A
TWIN RIVERS								
Northern clingfish	C	C	F	F	C	F	F	
High cockscomb	F	F	C	F	C	F	F	F
Black prickleback	F		F		F	F		
Rock prickleback	F	F	F		F		F	
Tidepool sculpin	C	C	C	C	C	C	C	C
OBSERVATORY POINT								
Northern clingfish	C	C	C	C	C	C	C	C
High cockscomb	A	A	A	A	A	A	A	A
Black prickleback	F	F	F	F	F	F	F	F
Rock prickleback	F		F		F	F		
Sharpnose sculpin	C	C	C	F	C	F	F	F
Mosshead sculpin	C	F	C	F	F	C	F	F
Tidepool sculpin	A	A	A	A	A	A	A	A
MORSE CREEK								
Northern clingfish	C	C	F	C	C	C	C	C
High cockscomb	C	C	C	C	C	A	C	C
Tidepool sculpin	A	C	A	A	A	A	A	A
NORTH BEACH								
Northern clingfish	C	F	F	F	C	C	F	F
High cockscomb	F	F	F	F	F	F	F	F
Tidepool sculpin	C	F	F	C	C	F	F	C

Table 13. Number of species (yearly total and three-year total) collected by beach seine at the sampling sites.

Site	1976-77	1977-78	1978-79	Total
Kydaka Beach	17	14	14	25
Twin Rivers	23	21	20	28
Morse Creek	28	29	29	42
Dungeness Spit	24	14	27	33
Jamestown-Port Williams	11	35	28	41
Beckett Point	51	46	42	65
West Beach		32		
Alexander's Beach		35		

Species richness exhibited similar seasonal trends in all years of the study. Maxima occurred in the summer and sometimes the fall; minima were recorded in the winter (Fig. 3). The most exposed sites (Kydaka Beach, Dungeness Spit) exhibited the greatest variations between seasons. Seasonal patterns in maximum and minimum species richness and the number of species collected within a season were quite similar at these sites. The most protected sites (Jamestown-Port Williams, Beckett Point, Alexander's Beach) exhibited the least seasonal variation in species richness, but the number of species collected was not comparable among the sites; the shallower sites (Jamestown-Port Williams, Alexander's Beach) yielded fewer species than the deeper site (Beckett Point). Sites of intermediate exposure (Twin Rivers, Morse Creek) exhibited some seasonal variation--species richness was lower in winter and spring than in summer and fall--and produced a comparable number of species.

Species richness values recorded in this study were similar to species richness values recorded in the San Juan Islands by Miller et al. (1977), with the exception of Beckett Point. The number of species collected at Beckett Point was greater in all seasons than the number of species collected in comparable habitats in northern Puget Sound, e.g., Deadman Bay. The high values at Beckett Point may have been the result of one or more of the following: (1) High abundance, diversity, and availability of food; (2) utilization of Discovery Bay as a nursery area by many species; (3) the proximity of two dissimilar habitats--a steep, sand slope and an eelgrass-covered mudflat.

Seasonal variation in the number of species collected in the San Juan Islands was similar to the variation observed at all but the most protected sites in the Strait of Juan de Fuca--high spring-summer values and low fall-winter values.

4.3.2 Townet

A yearly summary of the number of species caught at each site is presented in Table 14 and Appendix 6.4. Collections at sites in the eastern Strait of Juan de Fuca generally produced more species than sites in the western strait. Between-year variations in species richness at a particular

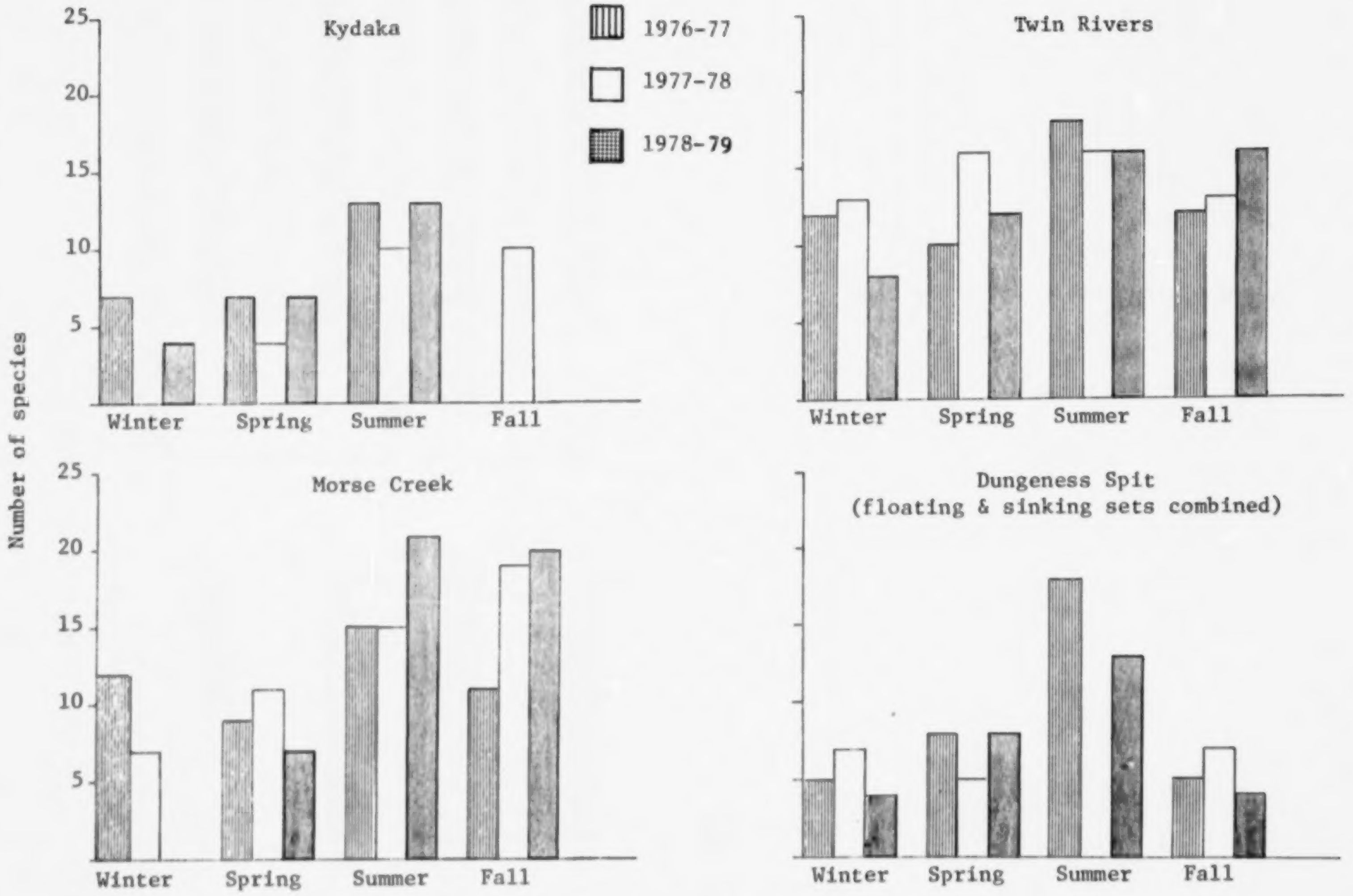

Fig. 3. Species richness of seasonal beach seine collections, 1976-1979.

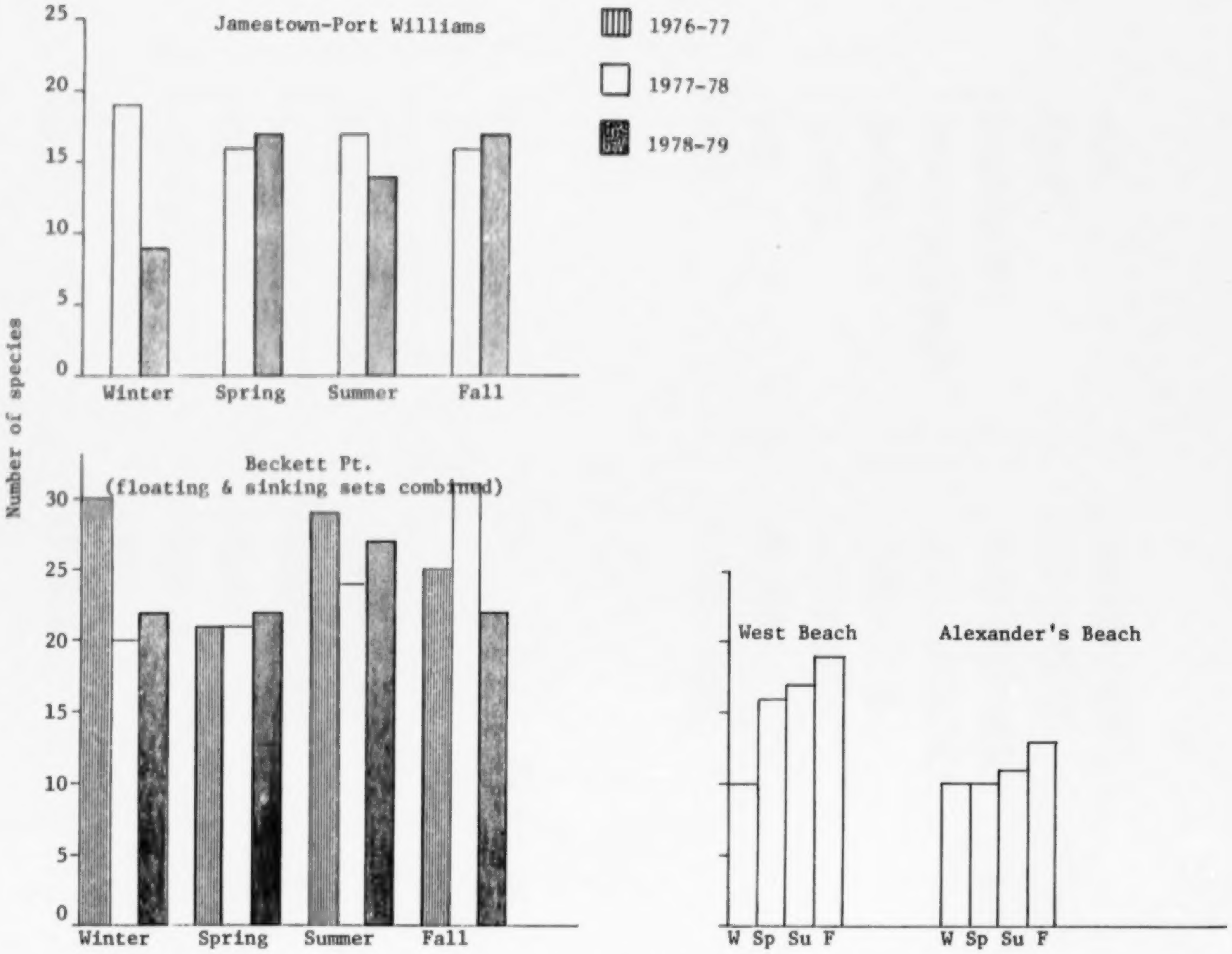

Fig. 3. (Contd.) Species richness of seasonal beach seine collections, 1976-1979.

Table 14. Number of species collected (yearly total and three-year total) by townet at the sampling sites.

Site	1976-77	1977-78	1978-79	Total
Kydaka Beach	14	11	18	23
Pillar Point	18	16	21	28
Twin Rivers	20	11	11	22
Morse Creek	25	20	18	34
Dungeness Spit	25	20	14	31
Jamestown-Port Williams	20	19	13	31
Beckett Point	25	15	17	30
West Beach		19		
Alexander's Beach		23		

site were generally the result of capturing juvenile individuals of demersal species, usually rare in townet catches.

Seasonal trends in species richness are evident (Fig. 4). Maxima usually occurred in the spring, and occasionally in the summer and fall; minima occurred in the winter. The occurrence of high values in the spring and summer represented the influx of larvae and juveniles into nearshore surface waters.

Seasonal trends in species richness in the Strait of Juan de Fuca paralleled the seasonal trends observed in northern Puget Sound (Miller et al. 1977). The number of species collected in the strait was generally higher than the number of species collected in the San Juan Islands but comparable to the number of species collected around Cherry Point and Anacortes (see Miller et al. 1977, for locations of northern Puget Sound sampling sites).

4.3.3 Intertidal

Species richness was higher on the rocky headlands (Neah Bay, Slip Point, Observatory Point) than on the cobble beaches (Twin Rivers, Morse Creek, North Beach) (Table 15, Appendix 6.5). This is probably a result of the predictability of the habitat--e.g., tidepools on rocky headlands are discrete and persist for long periods of time (at least three years and probably much longer) while tidepools on cobble beaches are less well defined and may change in size and shape (or disappear altogether) several times a year after storms (Cross, unpubl. data).

Table 15 also presents the number of transient species collected at each site. On the rocky headlands they were primarily juveniles of subtidal cottids (e.g., red Irish lord, buffalo sculpin, scalyhead sculpin) while on the cobble beaches they also included juvenile flatfish (English sole, rock sole) and larvae of schooling species (Pacific sand lance, Pacific herring). On all beaches the transient species were encountered only infrequently.

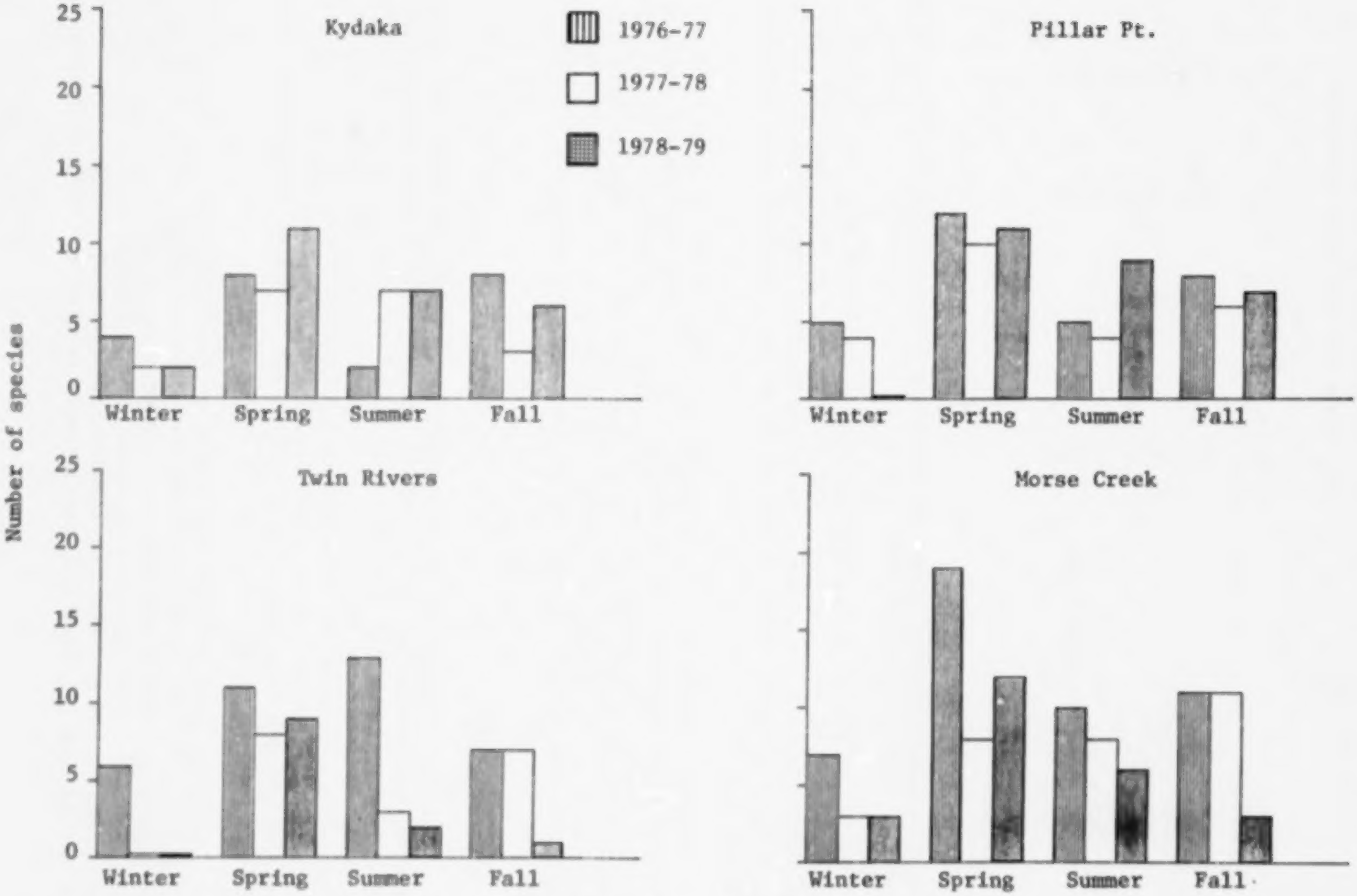

Fig. 4. Species richness of townet collections, 1976-1979.

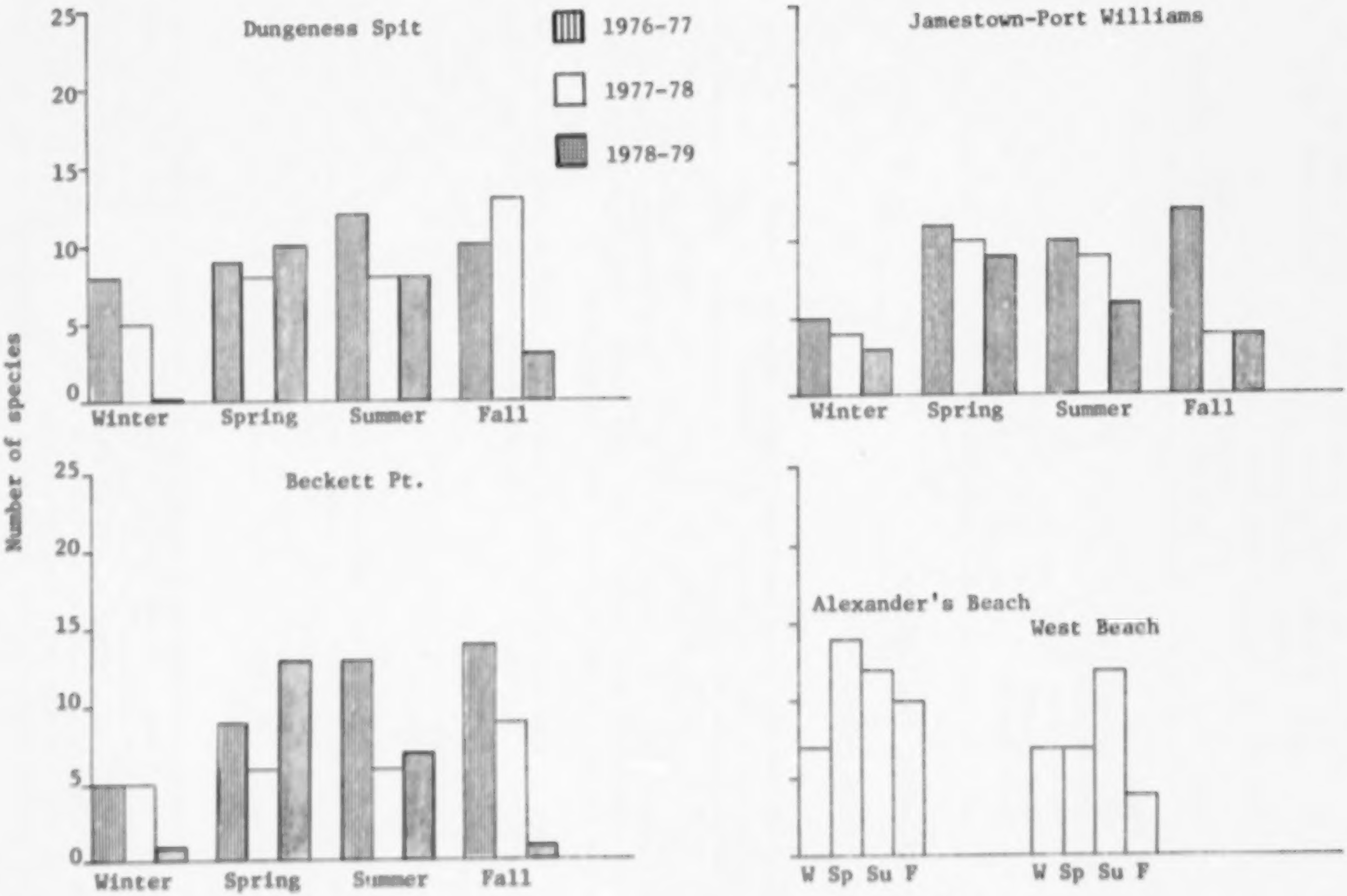

Fig. 4. (Contd.) Species richness of townet collections, 1976-1979.

Table 15. Number of resident and transient species collected at intertidal sampling sites. Data based on abundance (numbers) of fish collected over two years of sampling (1977-1978).

Site	Number of resident species	Number of transient species
Neah Bay	16	3
Slip Point	16	3
Twin Rivers	11	3
Observatory Point	16	6
Morse Creek	9	6
North Beach	6	9

4.4 NEARSHORE FISH DENSITY

4.4.1 Beach Seine

The density of fishes (number of fish per m^2) at the exposed and moderately exposed sites exhibited marked seasonal trends while at the protected sites the trends were less distinct (Fig. 5, Appendix 6.3). Maximum densities at the most exposed sites (Kydaka Beach, Dungeness Spit) were recorded in the summer; low values (< 0.2 fish per m^2) typified the remainder of the year. Schooling species (juvenile Pacific herring, Pacific sand lance) were responsible for the high summer densities. (Seasonal trends at the exposed Whidbey Island site, West Beach, were not evident probably because of the limited amount of data collected.)

Densities at the moderately exposed sites (Twin Rivers, Morse Creek) were generally highest in the summer and occasionally in the fall. Species responsible for the high densities were most frequently demersal (rosylip sculpin, English sole, sand sole) or pelagic but associated with the bottom (redtail surfperch) and less frequently, small schooling species (surf smelt, tube-snout).

Densities at the most protected sites were always among the highest recorded. Maxima occurred in summer and fall, and occasionally in some winter and spring collections. The high densities resulted from large catches of demersal species (Pacific staghorn sculpin, tidepool sculpin, English sole) and small schooling species (tube-snout, shiner perch, Pacific tomcod).

The highest densities recorded during the study occurred at the most exposed sites and were the result of pure catches of either Pacific herring or Pacific sand lance. The fact that large numbers of these species were not captured every summer at the exposed sites reflects the patchy distribution of the small schooling species and suggests a low probability of capture under a quarterly sampling scheme. The high densities at Beckett Point, second only to those recorded at the most exposed sites, were more

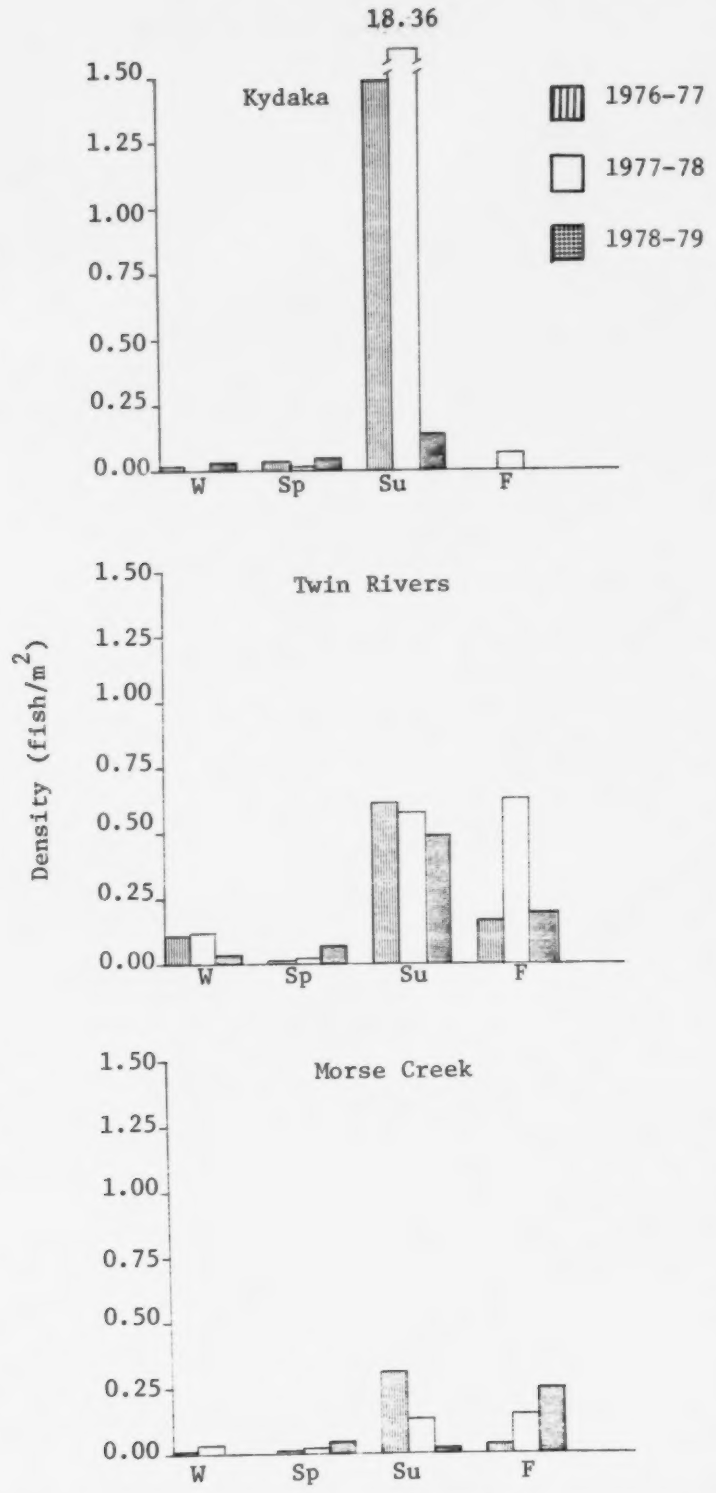

Fig. 5. Density of fish (# fish/m^2) of seasonal beach seine collections, 1976-1979.

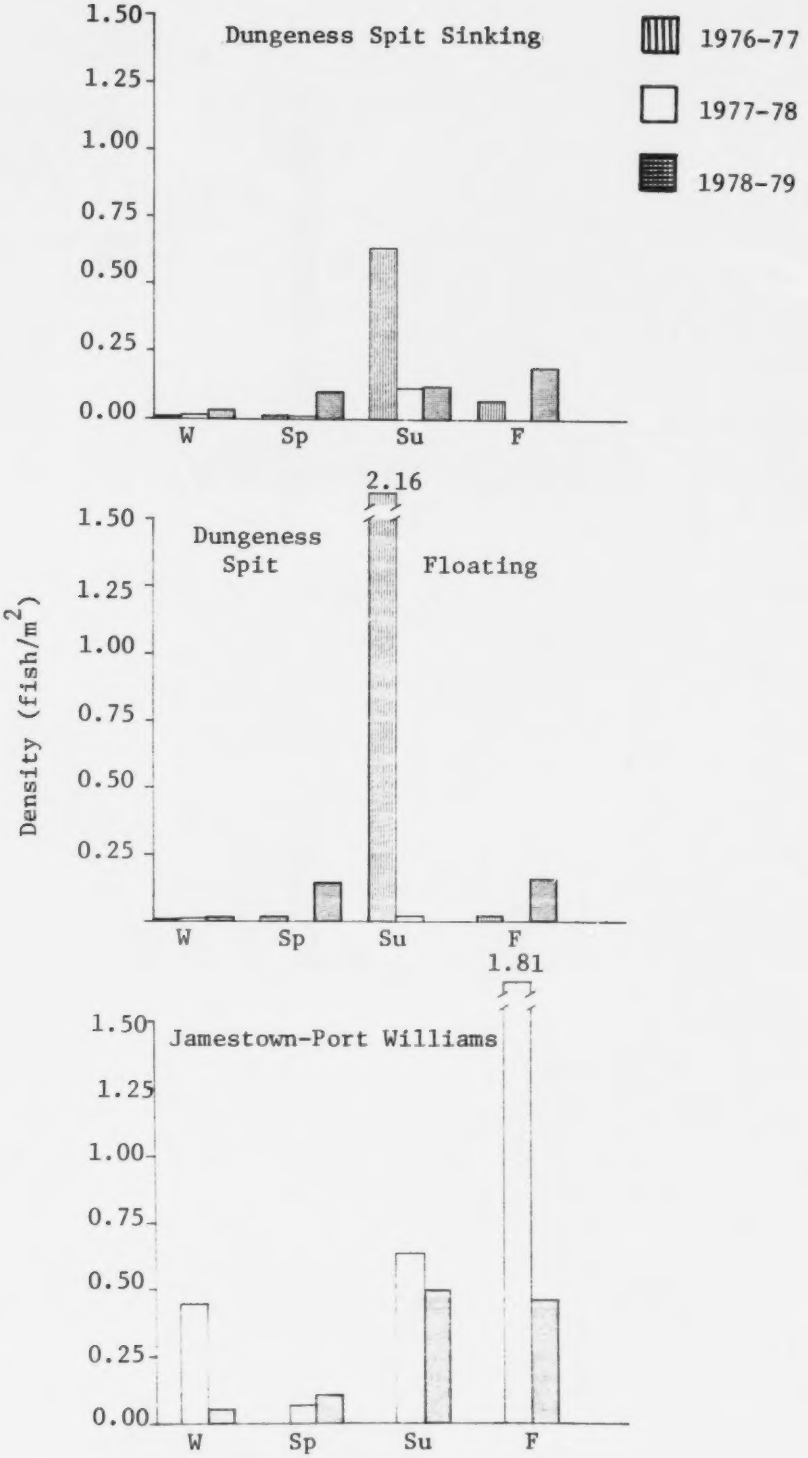

Fig. 5. (Contd.) Density of fish (# fish/m^2) of seasonal beach seine collections, 1976-1979.

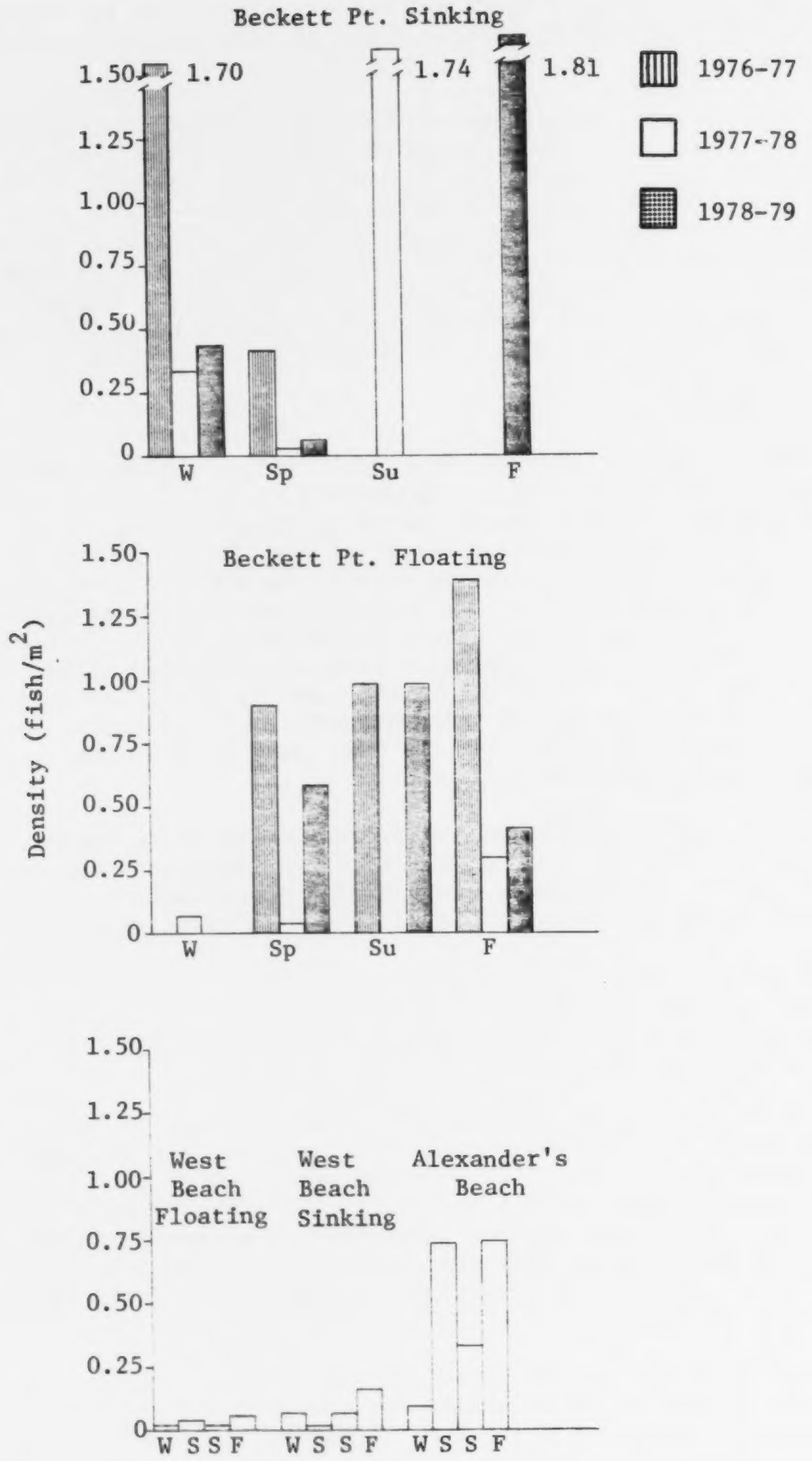

Fig. 5. (Contd.) Density of fish (# fish/m^2) of seasonal beach seine collections, 1976-1979.

varied in composition. The mixed catches of pelagic and demersal fish at Beckett Point reflect the variety, and perhaps the quality, of habitats at that site.

Both the seasonal trends and the magnitude of fish densities in the Strait of Juan de Fuca were comparable to the seasonal trends and magnitudes in northern Puget Sound (Miller et al. 1977), although densities at Beckett Point tended to be greater in spring than densities from similar habitats in northern Puget Sound. Utilization of nearshore habitats by demersal and schooling species was similar in the strait and northern Puget Sound. Schooling species were primarily responsible for the highest densities at the exposed sites while demersal species were of equal, and in some instances greater, importance at the more protected sites.

4.4.2 Townet

Fish densities (number per m^3) in townet collections were highest in the spring and summer (Fig. 6, Appendix 6.4), although at every site there was considerable within-season variation between years. The high densities at all sites were a result of large catches of post-larval and juvenile Pacific herring, and to a lesser extent, Pacific sand lance and longfin smelt. While Pacific herring and Pacific sand lance occurred at all sites, over 99% of the longfin smelt were collected at Pillar Point and Twin Rivers. The apparent proximity of spawnimg grounds (suspected to be the Pysht River and East and West Twin Rivers) to the sampling sites probably accounts for the localized occurrence of the longfin smelt. Interestingly, longfin smelt were captured only during the first two years of sampling; their absence in the third year cannot be explained.

The marked within-season variation between years may have been caused by the patchy distribution of the fish, resulting in a low probability of capture, or by variations in year class strength between years. It is therefore difficult to attach significance to these variations.

Minimum densities (< 0.6 fish per m^3) were recorded at all sites in fall and winter. Larval fish, which appeared in the water column in spring and had reached the juvenile stage by summer, had largely disappeared from the nearshore surface waters by fall.

Unlike beach-seine collections, obvious trends in townet collections between sites were largely absent--i.e., exposed sites exhibited densities equal to or greater than the protected sites. With the exception of the previously discussed longfin smelt, the conclusion is that Pacific herring and Pacific sand lance are not associated with particular habitats, but probably wander freely along the shoreline using it as a nursery area, and perhaps as a refuge from predation, during the spring and summer of their first year of life.

Fish densities in the Strait of Juan de Fuca tended to be greater than densities in the San Juan Islands and around Anacortes but comparable to densities recorded in the vicinity of Cherry Point (Miller et al. 1977).

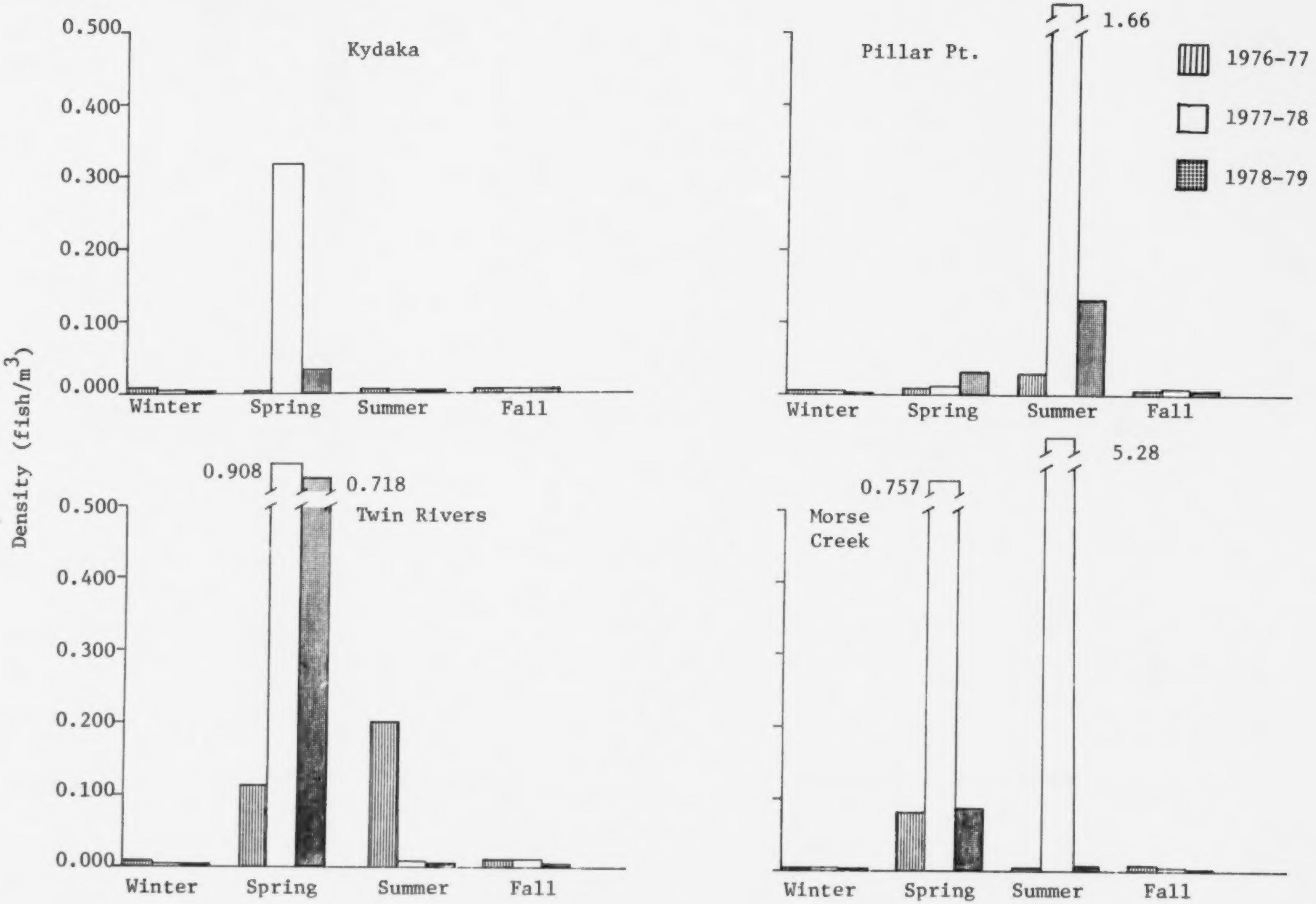

Fig. 6. Density (# fish/m^3) of fishes in seasonal townet collections, 1976-1979.

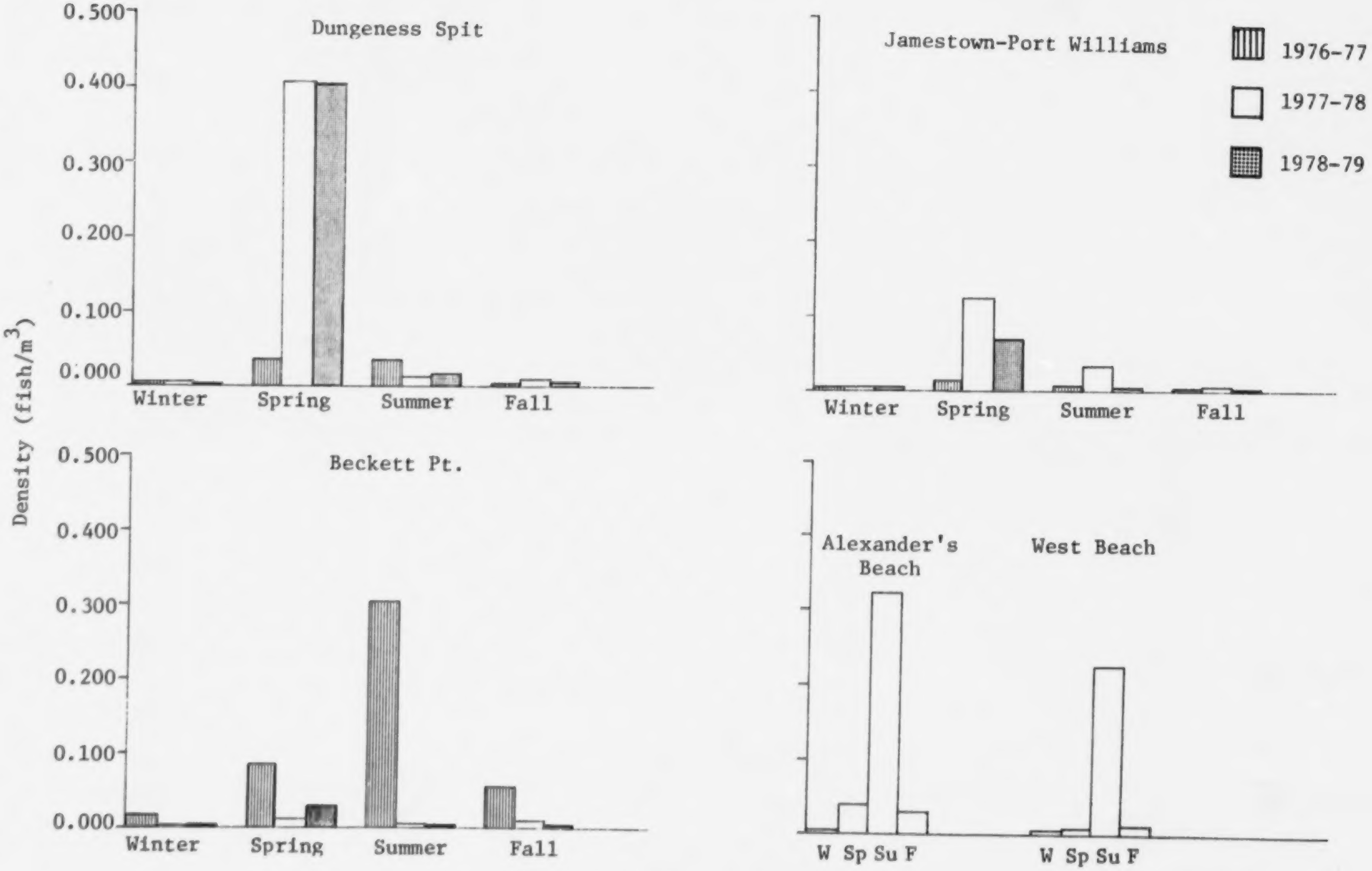

Fig. 6. (Contd.) Density (# fish/m^3) of fishes in seasonal townet collections, 1976-1979.

A marked difference between the Strait of Juan de Fuca and northern Puget Sound was the virtual absence of threespine stickleback from collections in the strait. In northern Puget Sound townet catches, stickleback ranked second in occurrence, second or third in abundance, and in the top ten in biomass, and occurred in all habitats from exposed to protected. The reason for its absence from the strait is unknown. With the exception of threespine stickleback, the composition of townet catches in northern Puget Sound was quite similar to townet catches in the strait.

4.4.3 Intertidal

Two types of habitat were sampled in the intertidal during low slack water: Tidepools and the beneath-rock habitats. Intertidal fish densities are presented as number of fish per m^2 (tidepools) and number of fish per rock (beneath-rock habitats) (Fig. 7, Appendix 6.5). Sculpin were generally the most abundant group in tidepools, followed by prickleback and gunnel ("blennies") and clingfish and snailfish ("others"). Prickleback and gunnel were generally the most abundant groups in the beneath-rock habitat, followed by cottids and others. The occasional high densities of cottids beneath rocks from late winter to early spring may have been spawning aggregations (Cross, unpubl. data).

The density of sculpin in tidepools was generally comparable among sites. The densities of blennies and others were similar at all sites except North Beach where densities were consistently lower. This is probably a result of the paucity of hiding places beneath or among rocks in the tidepools at North Beach. The intertidal at North Beach is heavily sedimented during late winter and spring. The sand may remain on the beach for months, filling holes and crevices otherwise used by blennies and others, reducing the available habitat and resulting in lowered fish densities. Sand is present on the other cobble beaches (Morse Creek, Twin Rivers) but accumulations are neither as great nor do they remain as long as on North Beach.

Densities of fish beneath rocks varied between sites; densities on the rocky headlands were generally greater than densities on the cobble beaches. This was most pronounced at North Beach where fish densities beneath rocks never exceeded one per rock. The abundance of sand on North Beach was undoubtedly the cause of the low densities.

Distinct seasonal trends in the density of fish in tidepools and beneath rocks were largely lacking, although a few generalizations can be made. Sculpin tended to be more abundant in tidepools from late winter to early summer, primarily because of an influx of juvenile sculpin from the plankton. The abundance of blennies in tidepools paralleled that of sculpin for the same reasons but to a lesser degree. The density of blennies beneath rocks generally exhibited an increase from late winter to early summer, again for the same reasons.

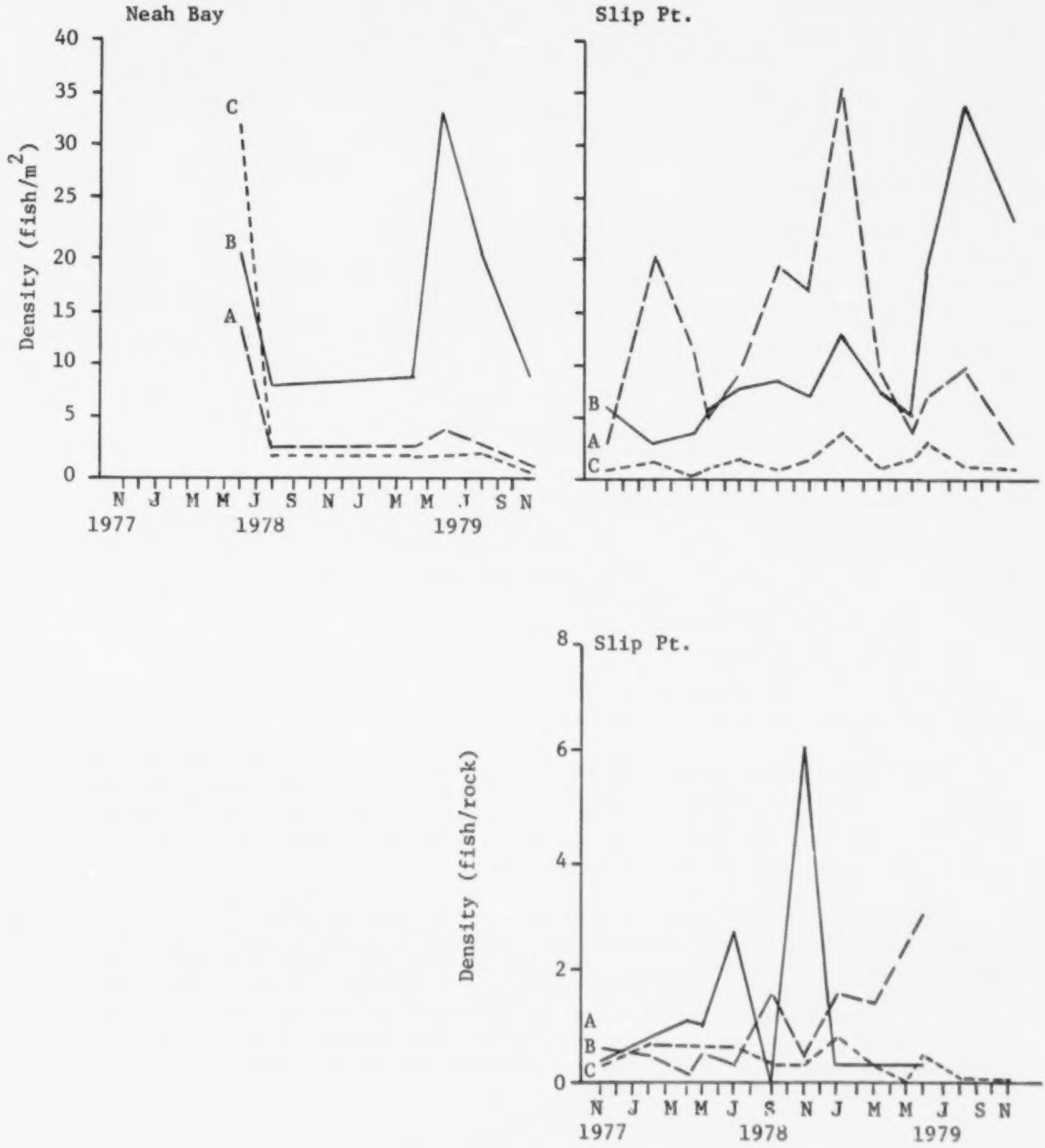

Fig. 7. Density of fish in tidepools (# fish/m^2) and beneath rocks (# fish/rock) in intertidal collections, 1977-1979. A. Prickleback and gunnel; B. sculpin; C. other.

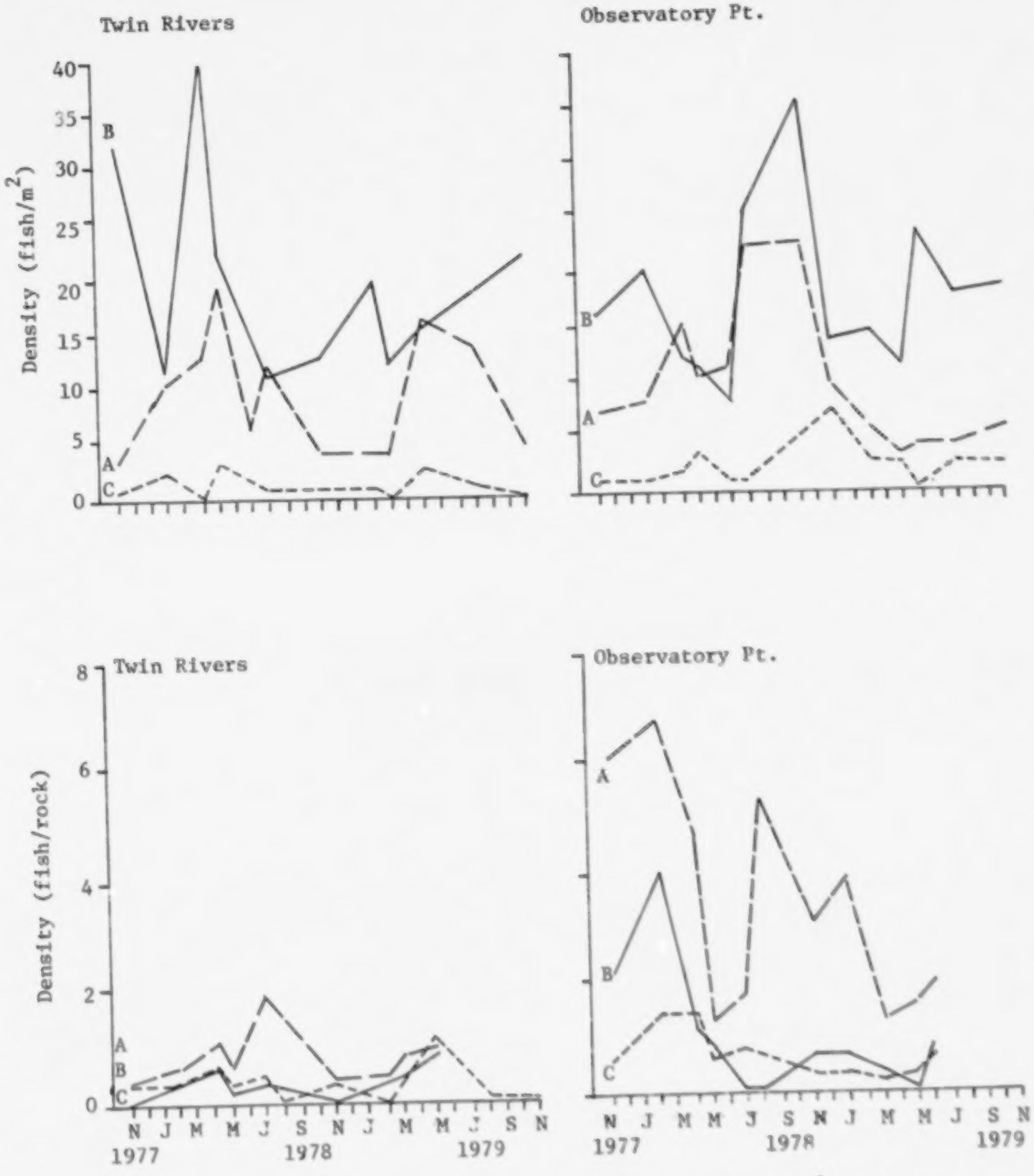

Fig. 7. (Contd.) Density of fish in tidepools (# fish/m^2) and beneath rocks (# fish/rock) in intertidal collections, 1977-1979. A. Prickleback and gunnel; B. Sculpin; C. Other.

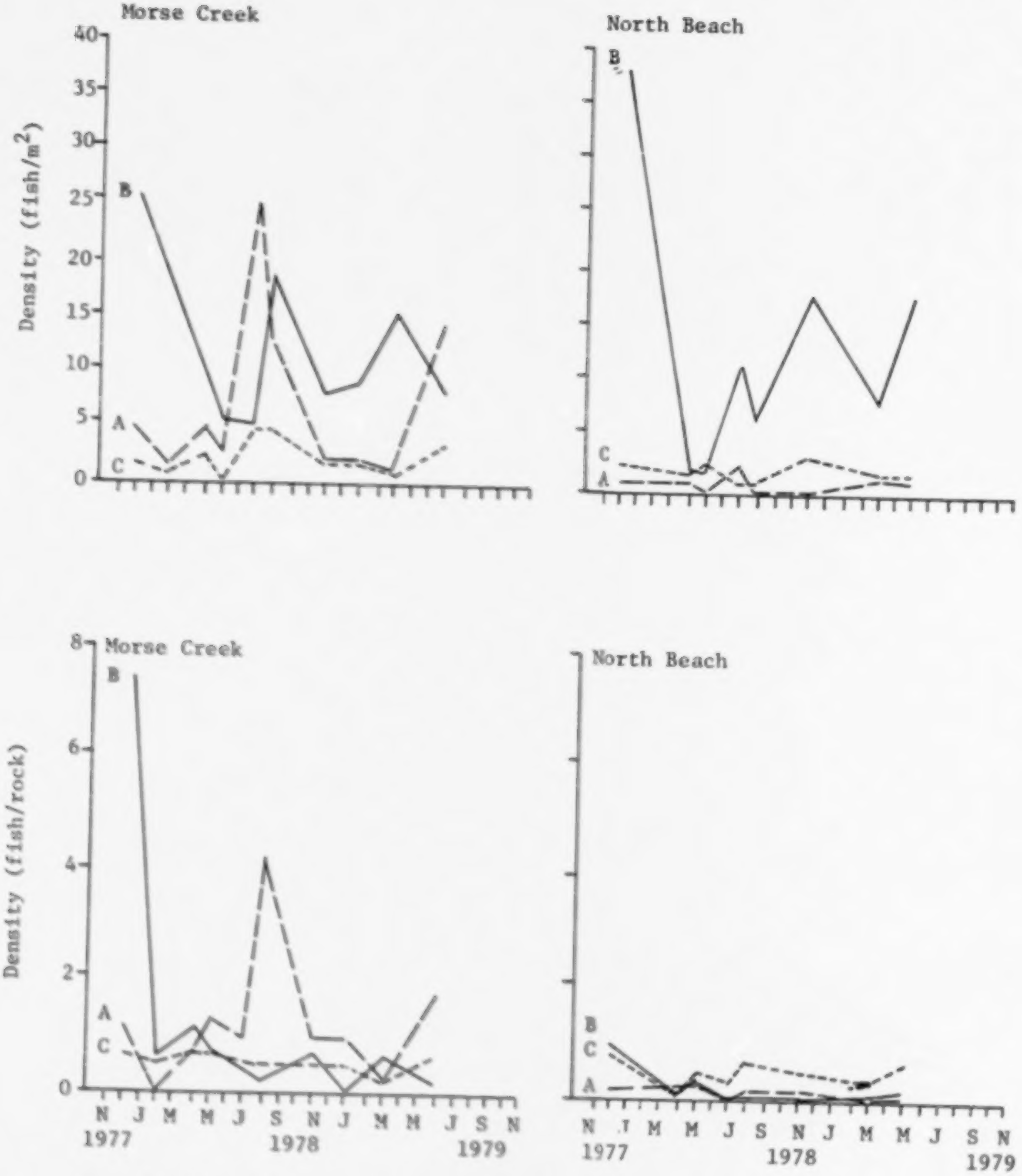

Fig. 7. (Contd.) Density of fish in tidepools (# fish/m^2) and beneath rocks (# fish/rock) in intertidal collections, 1977–1979. A. Prickleback and gunnel; B. Sculpin; C. Other.

4.5 NEARSHORE FISH STANDING CROP

4.5.1 Beach Seine

Seasonal trends in standing crop, although apparent, were not dramatic (Fig. 8, Appendix 6.3). At the most exposed sites (Kydaka Beach, Dungeness Spit), maximum biomass values were recorded in summer and fall and were highly influenced by the presence or absence of neritic species (Pacific herring, Pacific sand lance), and to a lesser extent by large demersal species (sand sole) and neritic species (spiny dogfish). Minimum biomass values at the exposed sites occurred in winter and spring.

Trends at the moderately exposed and protected sites were more varied. High values were recorded in all seasons; however, low values occurred in the winter (Morse Creek, Jamestown-Port Williams) or spring (Twin Rivers, Beckett Point). Contrary to the situation at the exposed sites, Pacific herring and Pacific sand lance contributed little to the standing crop at the moderately exposed and protected sites. High standing crop values at these sites were the result of large catches of small demersal species (juvenile Pacific staghorn sculpin, tidepool sculpin, rosylip sculpin), large demersal species (adult Pacific staghorn sculpin, starry flounder) or loosely aggregating, pelagic species (shiner perch, redtail surfperch, striped perch).

The lowest standing crop values (< 2 g per m^2) occurred at the most exposed sites. Low standing crop values, particularly in winter and spring, were probably the result of high turbulence generated by storms and tidal currents, and the homogeneous, low-relief character of the substrate. Food abundance and availability may also be reduced at such sites.

Standing crop values were greater at the moderately exposed and protected sites. Within-season variations between years were common. The highest standing crop values were recorded at a moderately exposed site (Twin Rivers); redtail surfperch, and to a lesser extent starry flounder, sand sole, and Pacific staghorn sculpin, were responsible for the high values.

Standing crop values recorded in the Strait of Juan de Fuca were comparable to values recorded in northern Puget Sound (Miller et al. 1977).

4.5.2 Townet

The standing crop of neritic fishes was usually greatest in summer; large catches were occasionally recorded in spring and fall (Fig. 9, Appendix 6.4). Pacific herring generally contributed the most to the standing crop at all sites. Spiny dogfish, because of their large size, contributed greatly to biomass estimates at three sites--Pillar Point, Dungeness Spit, and Jamestown-Port Williams. Some species were locally abundant and contributed significantly to biomass estimates: Longfin smelt at Pillar Point and Twin Rivers; surf smelt at West Beach and Alexander's Beach; and shiner perch, striped seaperch, and pile perch at Beckett Point.

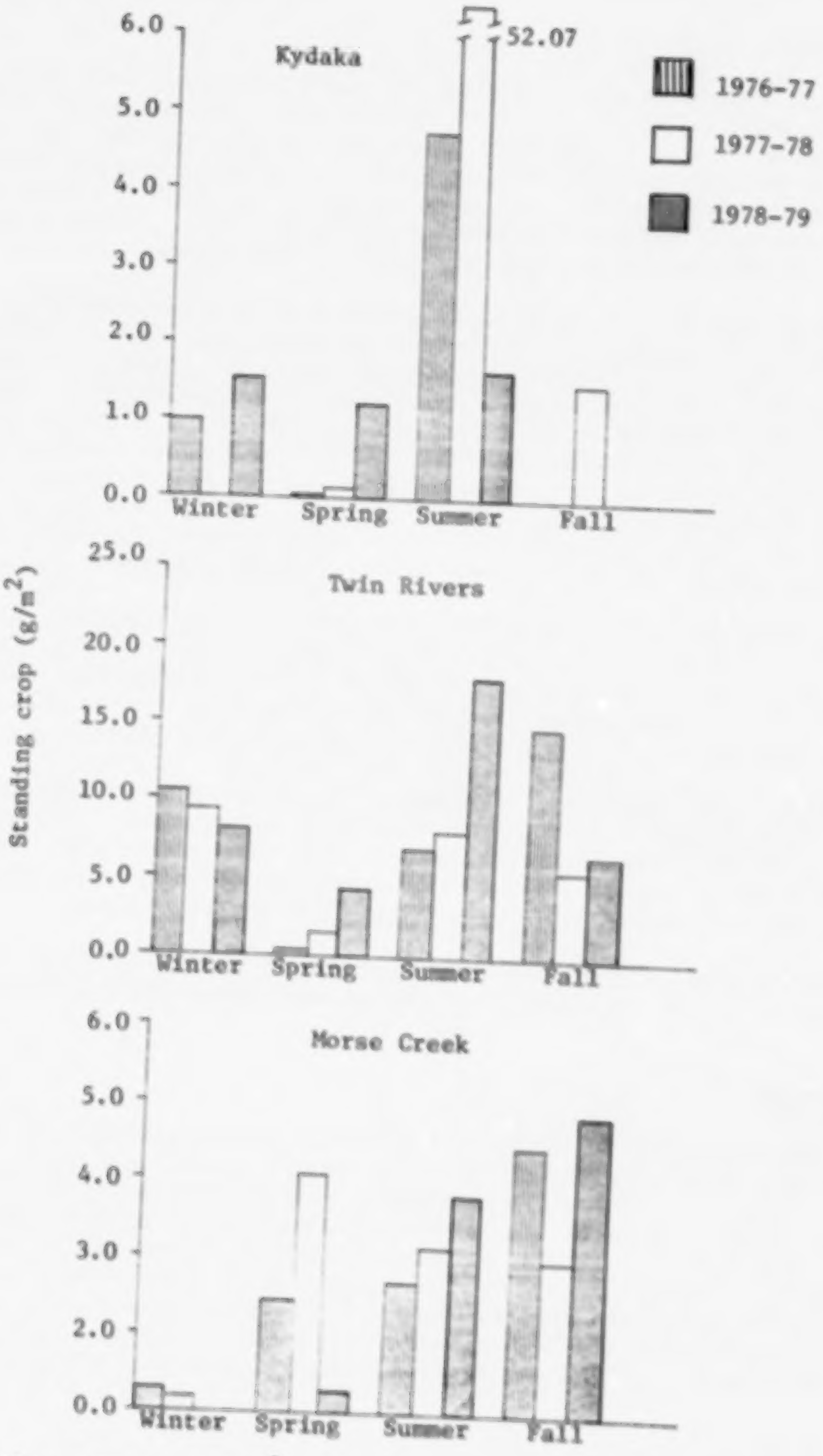

Fig. 8. Standing crop (g fish/m^2) of fishes in seasonal beach seine collections, 1976-1979. Note different scale for Twin Rivers.

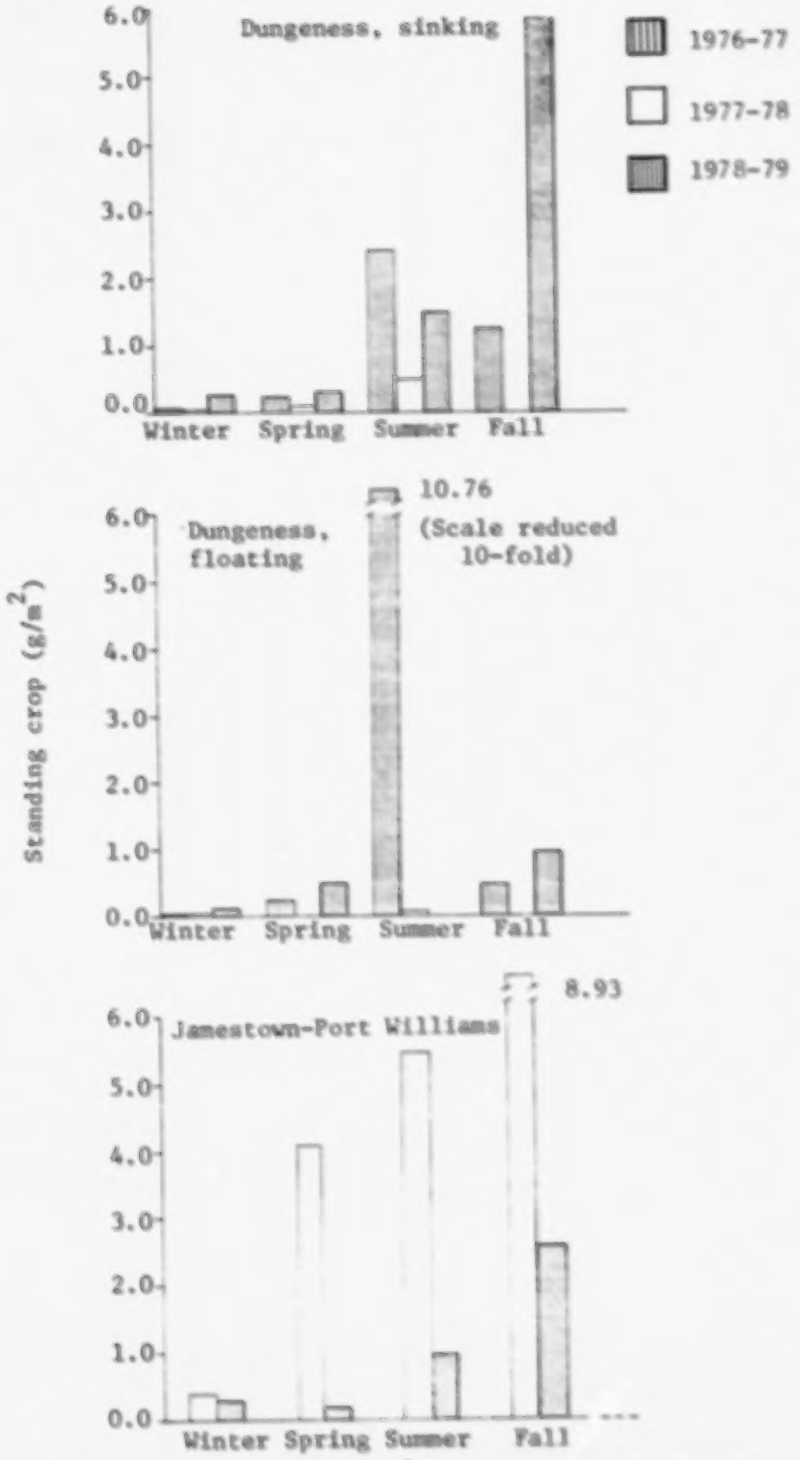

Fig. 8. (Contd.) Standing crop (g fish/m^2) of fishes in seasonal beach seine collections, 1976-1979.

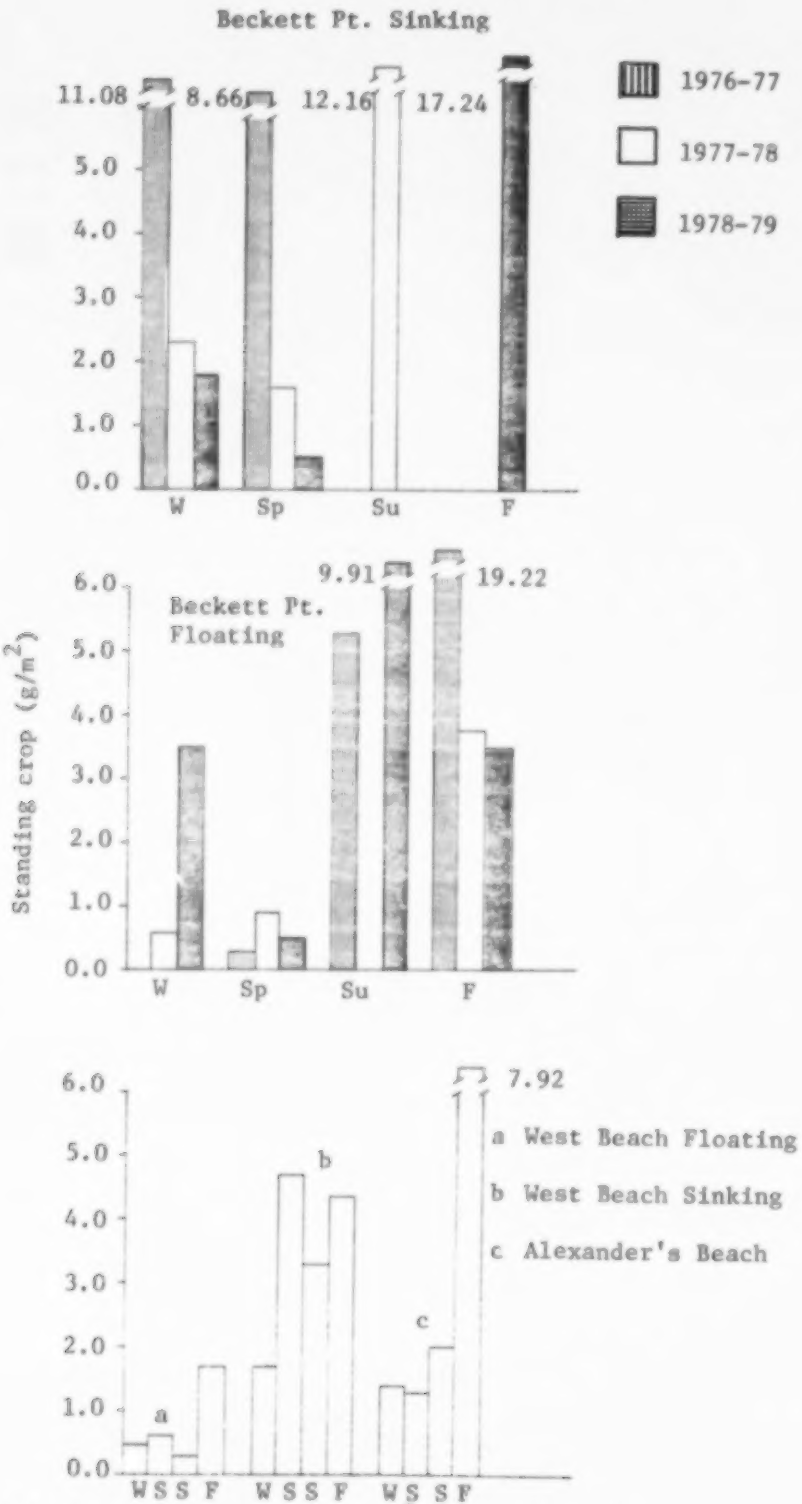

Fig. 8. (Contd.) Standing crop (g fish/m^2) of fishes in seasonal beach seine collections, 1976-1979.

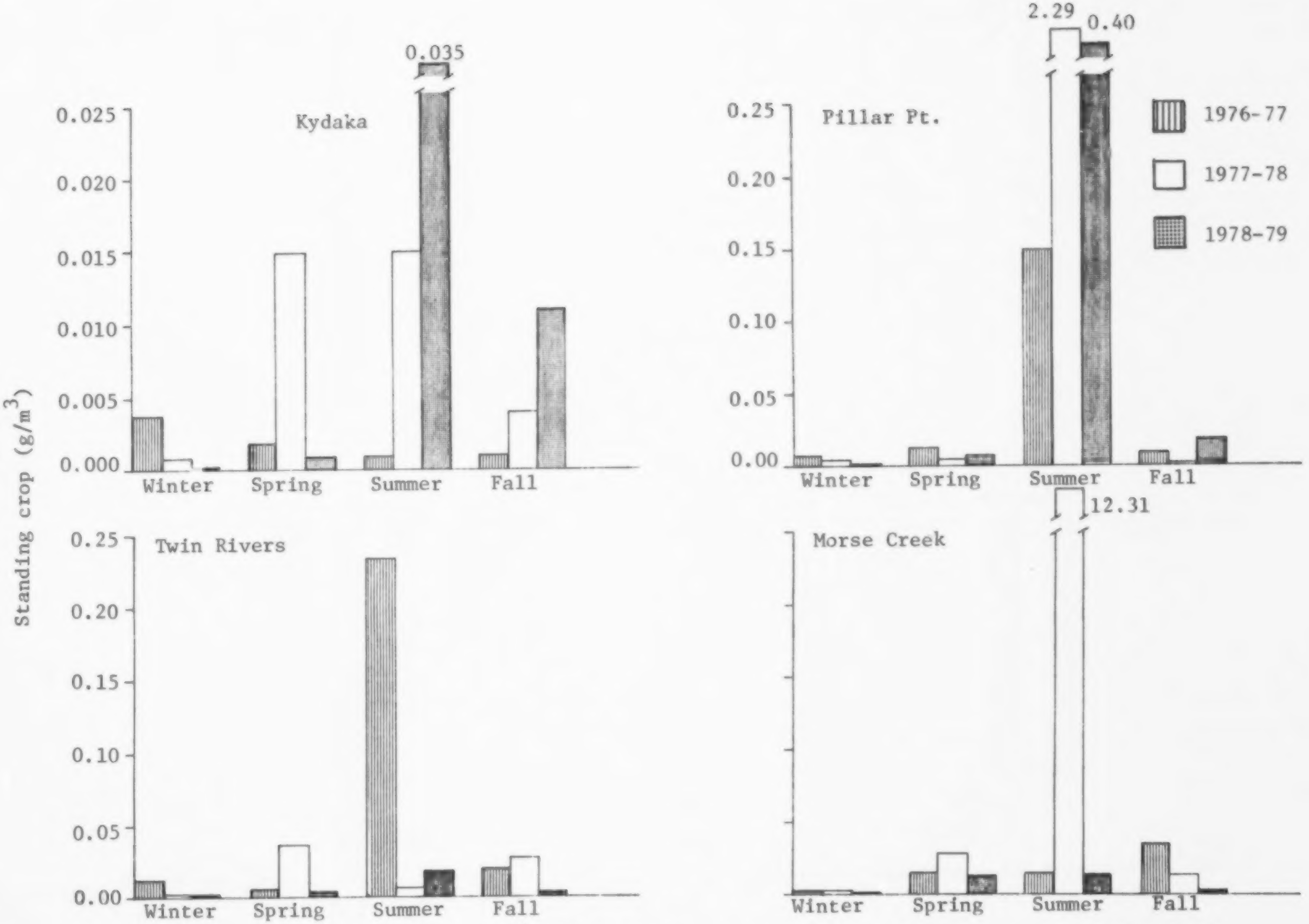

Fig. 9. Standing crop (g fish/m^3) of fish in seasonal townet collections, 1976-1979. Note different scale for Kydaka.

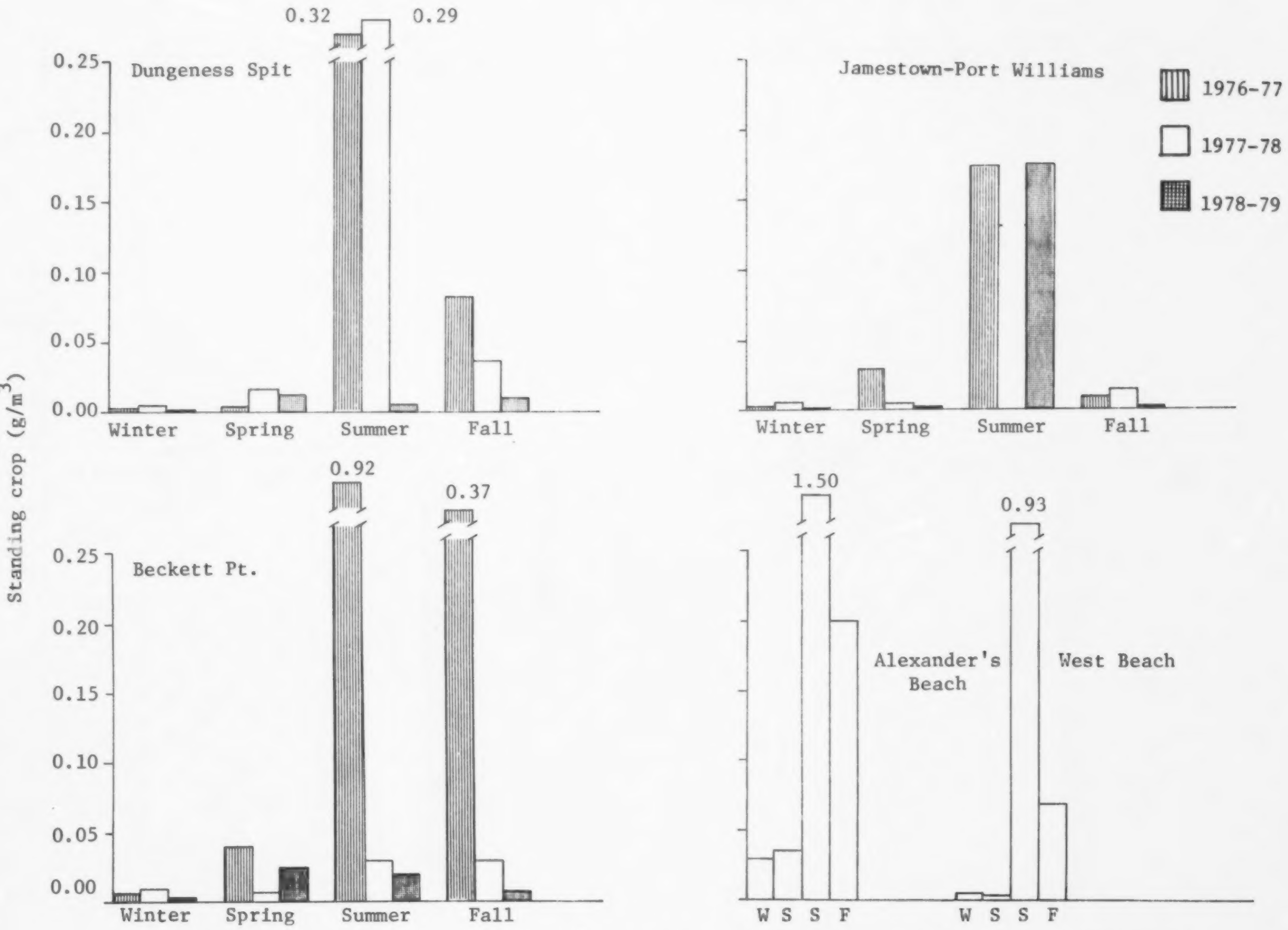

Fig. 9. (Contd.) Standing crop (g fish/m^3) of fish in seasonal townet collections, 1976-1979.

Because of the patchy distribution of neritic fishes, and consequently their unpredictable occurrence in townet catches, some minimum standing crop values occurred in all seasons. The within-season variations between years reflect this situation--e.g., standing crop values recorded in the summer were often as low as, or lower than, values recorded in the winter.

The other extreme is illustrated by the summer 1977-78 catch at Morse Creek. In two tows, more than 120,000 juvenile Pacific herring weighing nearly 300 kg were captured, which obviously exerted a substantial influence on standing crop estimates.

Nevertheless, standing crop values recorded in the Strait of Juan de Fuca were generally comparable to standing crop values recorded in northern Puget Sound by Miller et al. (1977). Standing crop values at the exposed sites in northern Puget Sound were not as high as at the protected sites, but this trend was not apparent in the Strait of Juan de Fuca. In both areas the sporadic occurrence of large individuals (e.g., spiny dogfish, starry flounder, and Pacific staghorn sculpin) often contributed significantly to standing crop estimates.

4.5.3 Intertidal

Standing crop values in tidepools exhibited marked variations and no consistent seasonal pattern (Fig. 10, Appendix 6.5). Sculpin and blennies were responsible for maxima in standing crop, but at different times of the year. The others, usually lower in biomass than either sculpin or blennies, occasionally exhibited high standing crop values. There were no apparent differences in the magnitude of standing crop between the rocky headlands and cobble beaches, although the composition of the fauna was often different.

Standing crop beneath rocks was generally dominated by blennies; sculpin and others contributed less to standing crop, but were usually equally represented. There were no consistent seasonal patterns in standing crop. Unlike the tidepool situation, there were differences in the magnitude of standing crop between the rocky headlands and cobble beaches; standing crop values were generally lower on the cobble beaches. This is exemplified by North Beach which had the lowest standing crop of any site. As previously mentioned, the reason for the low beneath-rock values was the high sediment accumulations which reduced the amount of available habitat, and consequently the standing crop of the fishes.

4.6 OCCURRENCE OF FIN ROT, LESIONS, TUMORS, AND PARASITES

No fin rot, lesions, or tumors were observed on any species of fish collected in the Strait of Juan de Fuca during the three years of study. Five English sole (70-182 mm TL) from beach-seine collections and one English sole (112 mm TL) from townet collections at Alexander's Beach and West Beach (August and October 1977) had skin tumors (epidermal papillomas). The tumor incidence, however, was less than one percent in collections with tumored fish. No fin rot or lesions were encountered on any species collected on Whidbey or Fidalgo Islands in 1977-78.

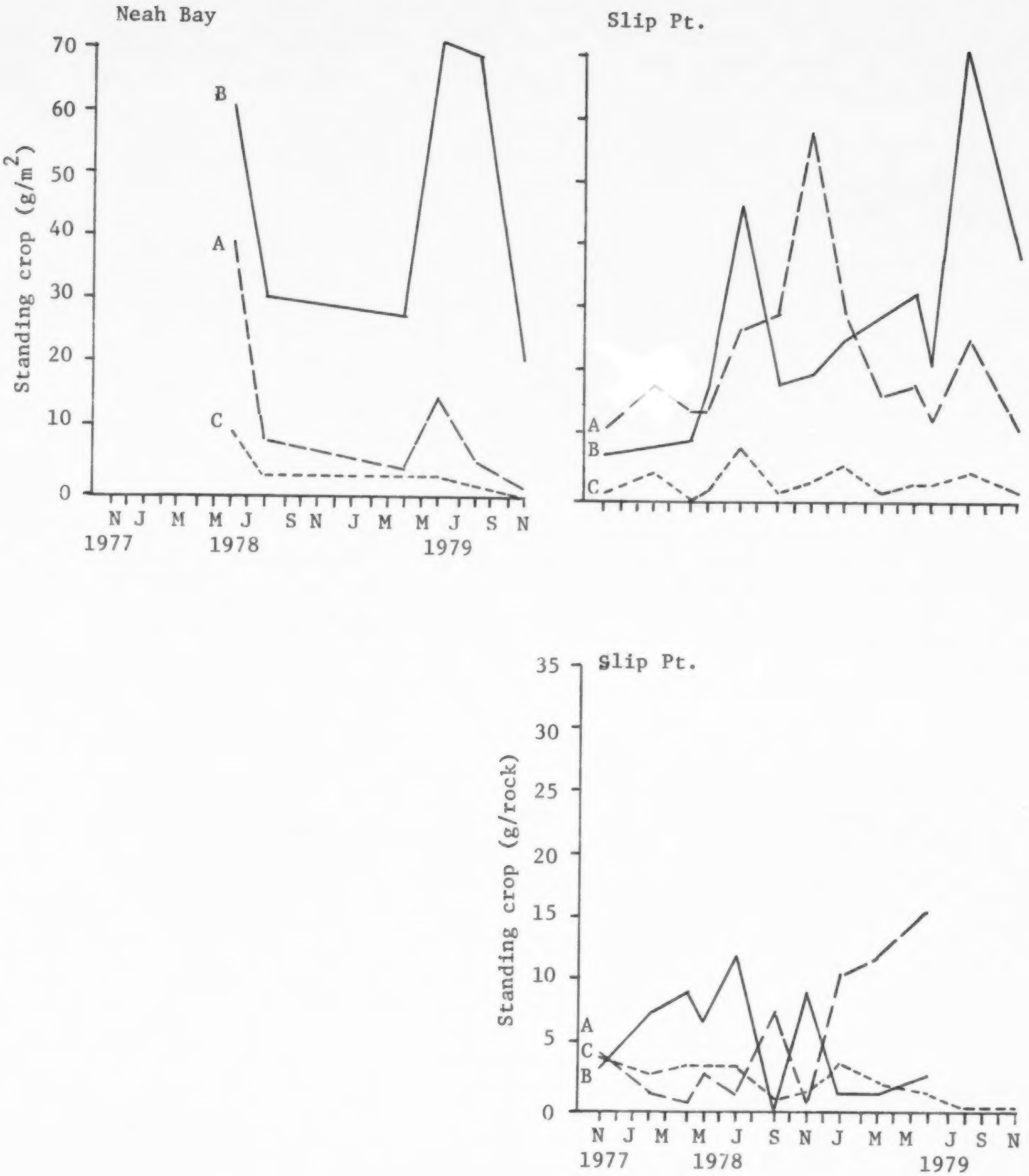

Fig. 10. Standing crop of fishes in tidepools (g fish/m^2) and beneath rocks (g fish/rock) in intertidal collections, 1977-1979. A. Prickleback and gunnel; B. Sculpin; C. Other.

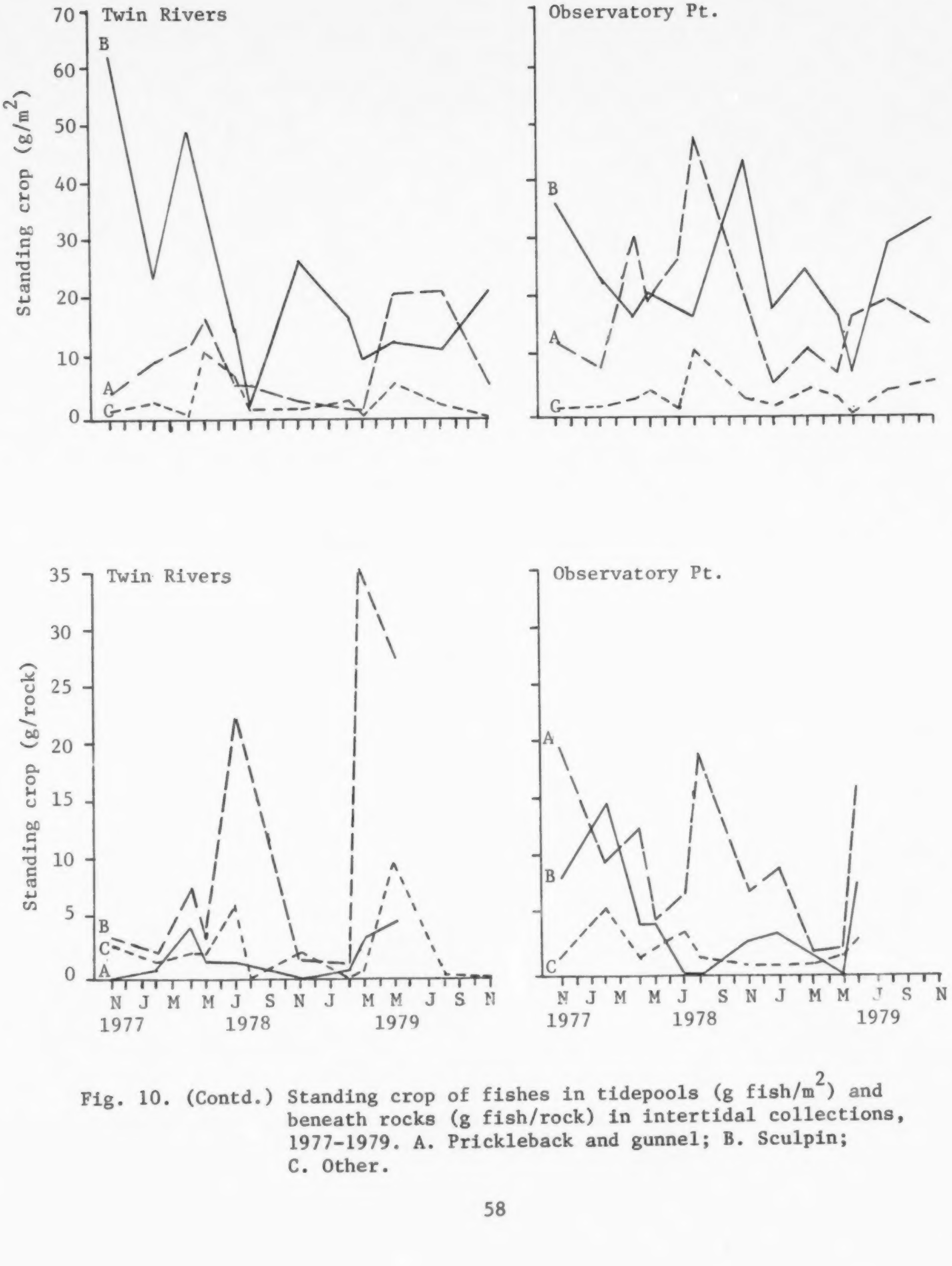

Fig. 10. (Contd.) Standing crop of fishes in tidepools (g fish/m^2) and beneath rocks (g fish/rock) in intertidal collections, 1977-1979. A. Prickleback and gunnel; B. Sculpin; C. Other.

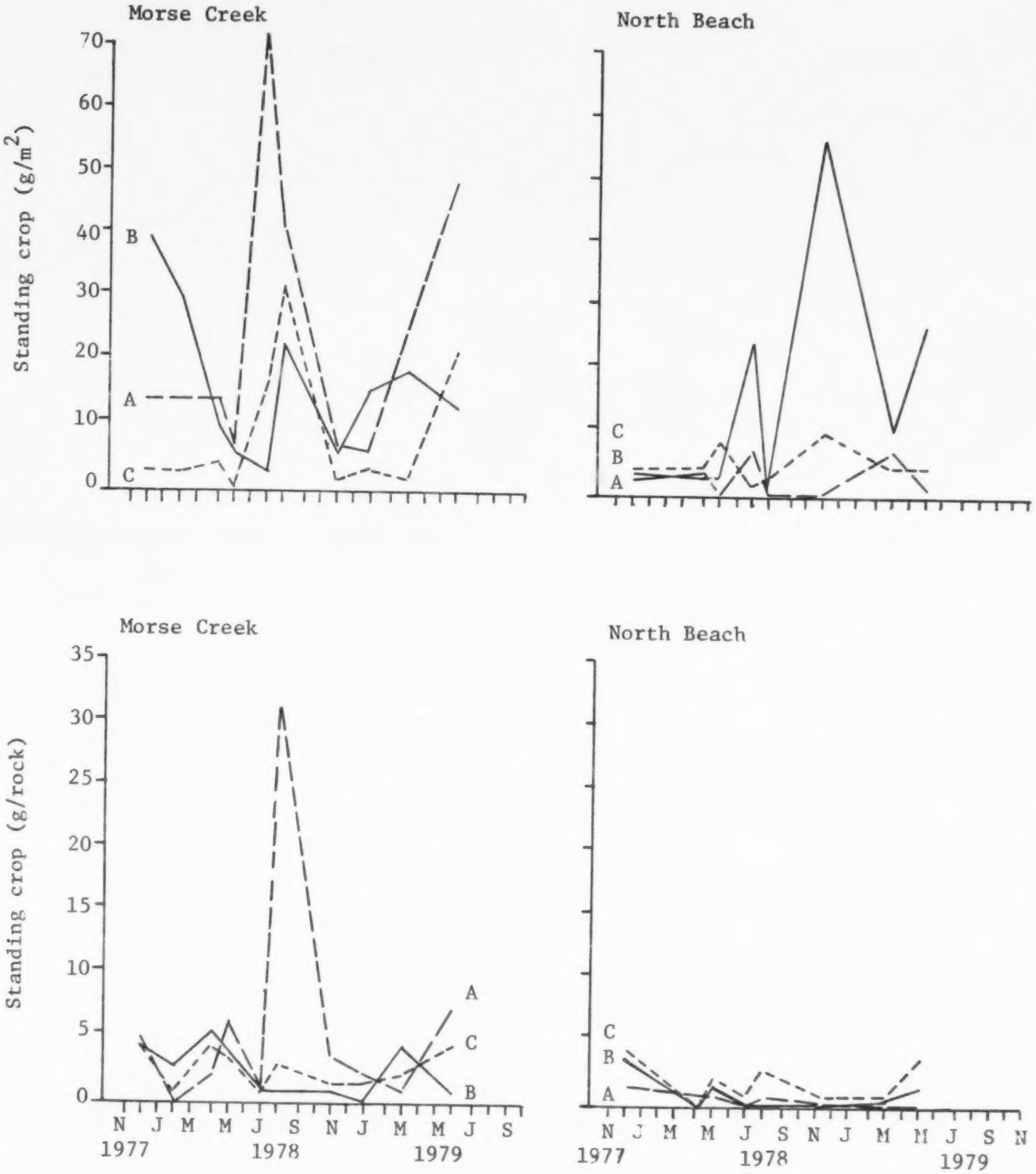

Fig. 10. (Contd.) Standing crop of fishes in tidepools (g fish/m^2) and beneath rocks (g fish/rock) in intertidal collections, 1977-1979. A. Prickleback and gunnel; B. Sculpin; C. Other.

Table 16. Summary of parasitized fish caught by beach seine during the three years of study.

Species	Life history stage	Number parasitized	Station	Season	Year	Parasite	Location
Longfin smelt	juvenile	1	Dungeness Spit	spring	76-77	copepod	external
Cutthroat trout	adult	1	Pt. Williams	spring	77-78	leech	external
Chinook salmon	adult	1	Dungeness Spit	spring	76-77	cestode	intestine
Pacific tomcod	juvenile	1	Beckett Pt.	winter	77-78	copepod	external
	juvenile	3	Morse Ck.	winter	78-79	copepod	gill chamber
Redtail surfperch	adult	4	Twin Rivers	winter	76-77	copepod	external
	adult	4	Twin Rivers	winter	78-79	copepod	external
Striped seaperch	adult	1	Beckett Pt.	spring	76-77	copepod	external
	adult	1	Morse Ck.	spring	76-77	copepod	external
	juvenile	1	Twin Rivers	winter	76-77	copepod	external
	adult	2	Dungeness Spit	winter	77-78	copepod	external
	adult	1	Twin Rivers	winter	78-79	copepod	external
Penpoint gunnel	adult	1	Pt. Williams	spring	77-78	copepod	external
Padded sculpin	juvenile	1	Dungeness Spit	winter	77-78	copepod	external
Silverspotted sculpin	juv/adult	4	Twin Rivers	winter	76-77	copepod	external
	adult	1	Pt. Williams	spring	77-78	copepod	external
Buffalo sculpin	adult	2	Jamestown	summer	76-77	nematodes	intestine
	juvenile	1	Beckett Pt.	winter	77-78	copepod	external
	juv/adult	2	Twin Rivers	summer	78-79	leech	external
	juvenile	8	Morse Ck.	winter	78-79	copepod	gill chamber

Table 16. (Contd.)

Species	Life history stage	Number parasitized	Station	Season	Year	Parasite	Location
Sharpnose sculpin	juvenile	1	Pt. Williams	summer	77-78	copepod	gill chamber
	adult	3	Pt. Williams	fall	77-78	copepod	external
	adult	2	Morse Ck.	winter	77-79	copepod	gill chamber
Pacific staghorn sculpin	juvenile	1	Twin Rivers	winter	76-77	nematode	intestine
	adult	1	Twin Rivers	spring	77-78	copepod	external
	adult	1	Beckett Pt.	spring	77-78	copepod	external
	adult	1	Beckett Pt.	fall	77-78	nematode	intestine
Cabezon	adult	2	Beckett Pt.	spring	77-77	copepod	external
Great sculpin	adult	2	Pt. Williams	spring	77-78	leeches, copepod	external
Tidepool snailfish	adult	1	Pt. Williams	fall	77-78	copepod	gill chamber
English sole	juvenile	1	Pt. Williams	summer	78-79	copepod	external
Sand sole	juvenile	1	Kydaka Beach	spring	77-78	copepod	external

The summary of parasitized fish caught by beach seine is presented in Table 16. Nineteen species in eight families were found with parasites; the incidence of parasitism exceeded one percent (in a sample) only once. The incidence of internal parasitism is not considered representative since only a small proportion of each catch were dissected. The incidence of external parasites is probably also underestimated because only those individuals having conspicuous parasites were discovered during processing.

Parasitized fish occurred at all sites in all seasons but were most frequently encountered in winter and spring. External parasitic copepods were observed most often because of their high visibility. Copepods were found on fishes possessing a variety of modes of life: Schooling species (longfin smelt, Pacific tomcod), aggregating species (redtail surfperch, striped seaperch), and a variety of demersal forms (sculpins and flatfish).

Few parasites were observed in the intertidal fish collections (Table 17). The low incidence of external parasites may be a function of a small surface area of the potential hosts (the two parasitic copepods observed were in the gill chambers), or possibly the fact that intertidal fish, which are highly thigmotactic, dislodge external parasites during their close contact with the substrate.

Table 17. Summary of parasitized fish from intertidal collections during 1977 and 1978.

Species	Number infested	Station	Date	Parasite	Location
Rosylip sculpin, adult	1	Observatory Point	Winter 1978	Copepod	Gill chamber
Saddleback sculpin, juvenile	1	Slip Point	Winter 1978	Copepod	Gill chamber
Ringtail snailfish, juvenile	1	Morse Creek	Winter 1978	Copepod	Gill chamber

4.7 DETECTING CHANGES IN FISH ABUNDANCE AND BIOMASS AFTER A PERTURBATION

One of the primary objectives of most baseline surveys is to provide information (composition, abundance, biomass, etc.) about a community that will enable researchers to detect alterations caused by subsequent perturbation (e.g., an oil spill). The first step toward the goal of providing reliable pre-perturbation information is the assessment of the variability of the baseline data. Our approach in this study is based on statistical hypothesis testing of data fitting a normal distribution. For example, if one is interested in testing for differences between the means of two samples, a null hypothesis is constructed (expressing no difference between means) as is an alternative hypothesis (expressing a difference between means). Knowing the variance of the two sample distributions allows a comparison of the two means statistically. The objective criterion for rejecting the null hypothesis in a statistical test is the significance level (denoted by α), which is generally a probability of 0.05. Occasionally, a true hypothesis will be rejected; this is called Type I error and occurs with a frequency of α. Alternatively, if the null hypothesis is actually false, the test may not detect it and one accepts a false hypothesis, which is called Type II error (denoted by β). The power ($1-\beta$) of a statistical test is the probability of rejecting the null hypothesis when it is in fact false and should be rejected (Zar 1974). In this study, power was used to answer the following question: After an oil spill, what is the probability of detecting a change in the number or biomass of the fish at a particular site in a particular season? Number and biomass were chosen because they are easily measurable with the techniques employed in this study and because communities respond to perturbations with changes in these parameters.

The number and biomass of fish caught seasonally at a particular site over the three years of the study represented the distribution of the catches. The data were transformed by taking the logarithm to homogenize the variance. Mean and standard deviations of the transformed data were calculated. The next step in computing power was to make two assumptions: (1) The result of an oil spill would be a decrease in the number and biomass of fish at the affected site; and (2) the variance of the catches would not change before and after the oil spill. The first assumption is reasonable; the second is more open to question. Finally, a series of hypothesized post-perturbation catches (number and biomass) were constructed. The hypothesized values corresponded to decreases of 50%, 75%, 90%, and 95% of the mean number and biomass of catches at a particular site in a particular season recorded during this study. For example, if the mean number of fish caught at Twin Rivers in the winter for all three years was 100, the hypothesized mean abundances after an oil spill were 50, 25, 10, and 5 (these values were assumed to be the mean of several sets and were log transformed before calculating power). Recalling the assumption of equal variances, this results in two normal distributions with means $\bar{X}_1$ and $\bar{X}_2$ and variance S_1 ($\bar{X}_1$ corresponds to the mean of the six sets completed during this study and $\bar{X}_2$ corresponds to the mean of several sets made after an oil spill). The null hypothesis was that there was no difference between $\bar{X}_1$ and $\bar{X}_2$; the alternative was that there was a difference.

Power was calculated (Sokal and Rolf 1969) for number and biomass at every site in every season for the beach-seine and townet data (Tables 18, 19). The tidepool data were not amenable to this operation because the sampling design did not permit estimates of number and biomass for the intertidal collections as a whole. An important point to bear in mind when analyzing the results is that when $\bar{X}_1$ and $\bar{X}_2$ are close, the ability to detect differences, i.e., power, is reduced.

4.7.1 Beach Seine

The probability of detecting decreases of 75% or more in numbers and biomass during any season at a particular site was fairly high. For numbers it was generally high in summer, fall, and winter collections; for biomass it was high in summer and fall collections. Spring was the most variable (greatest range of probabilities) season for both numbers and biomass, probably because of the influx of fish into shallow water.

Table 18. The probability of rejecting the null hypothesis that there has been no decrease in numbers or biomass in beach seine collections when in fact the null hypothesis is false, i.e., there has been a decrease. The decrease is percent decrease from the mean numbers and biomass of fish collected during the three years of the study. Blanks indicate insufficient data for the analysis.

Season	Site	Biomass (% decrease)				Numbers (% decrease)			
	S = sinking F = floating	50%	75%	90%	95%	50%	75%	90%	95%
Spring	Kydaka Beach	.770	.999	.999	.999	.405	.965	.989	.999
	Twin Rivers	.064	.397	.919	.999	.722	.913	.999	.999
	Morse Creek	.028	.174	.636	.905	.038	.302	.867	.992
	Dungeness Spit (S)	.040	.224	.712	.941	.026	.215	.767	.970
	Dungeness Spit (F)	.152	.560	.956	.999	.038	.174	.564	.841
	Jamestown - Port Williams	.023	.117	.456	.752	.397	.851	.996	.999
	Beckett Point (S)	.019	.119	.512	.826	.026	.251	.844	.989
	Beckett Point (F)	.056	.312	.832	.980	.670	.999	.999	.999
Summer	Kydaka Beach	.788	.999	.999	.999	.012	.109	.560	.883
	Twin Rivers	.363	.962	.999	.999	.999	.999	.990	.999
	Morse Creek	.743	.999	.999	.999	.883	.999	.999	.999
	Dungeness Spit (S)	.468	.984	.999	.999	.227	.883	.999	.999
	Dungeness Spit (F)	-	-	-	-	-	-	-	-
	Jamestown - Port Williams	.095	.386	.855	.981	.417	.946	.999	.999
		-	-	-	-	-	-	-	-
	Beckett Point (S)	-	-	-	-	-	-	-	-
Fall	Kydaka Beach	-	-	-	-	-	-	-	-
	Twin Rivers	.705	.999	.999	.999	.599	.997	.999	.999
	Morse Creek	.979	.999	.999	.999	.295	.875	.999	.999
	Dungeness Spit (S)	-	-	-	-	-	-	-	-
	Dungeness Spit (F)	.824	.999	.999	.999	.145	.595	.974	.999
	Jamestown - Port Williams	.212	.699	.988	.999	.127	.472	.908	.999
	Beckett Point (S)	-	-	-	-	-	-	-	-
	Beckett Point (F)	.421	.967	.999	.999	.305	.898	.999	.999
Winter	Kydaka Beach	.433	.966	.999	.999	.797	.999	.999	.999
	Twin Rivers	.947	.999	.999	.999	.712	.999	.999	.999
	Morse Creek	.000	.000	.999	.999	.992	.999	.999	.999
	Dungeness Spit (S)	.149	.716	.997	.999	.195	.552	.925	.999
	Dungeness Spit (F)	.009	.066	.359	.695	.233	.871	.999	.999
	Jamestown - Port Williams	.258	.819	.999	.999	.034	.508	.946	.999
	Beckett Point (S)	.176	.791	.999	.999	.258	.900	.999	.999
	Beckett Point (F)	-	-	-	-	-	-	-	-

Table 19. The probability of rejecting the null hypothesis that there has been no decrease in numbers or biomass in townet collections when in fact the null hypothesis is false, i.e., there has been a decrease: the decrease is percent decrease from the mean numbers and biomass of fish collected during the three years of the study. Blanks indicate insufficient data for the analysis.

Season	Site	Biomass (% decrease)				Numbers (% decrease)			
		50%	75%	90%	95%	50%	75%	90%	95%
Spring	Kydaka Beach	.037	.309	.887	.994	.006	.063	.401	.761
	Pillar Point	.044	.274	.805	.976	.192	.595	.955	.998
	Twin Rivers	.081	.386	.883	.990	.079	.386	.883	.990
	Morse Creek	.176	.684	.983	.999	.051	.184	.528	.791
	Dungeness Spit	.149	.674	.992	.999	.082	.460	.946	.999
	Jamestown- Port Williams	.047	.425	.963	.999	.140	.614	.983	.999
	Beckett Point	.026	.179	.666	.927	.149	.742	.998	.999
Summer	Kydaka Beach	.056	.326	.853	.986	.127	.618	.986	.999
	Pillar Point	.024	.099	.352	.622	.006	.036	.187	.421
	Twin Rivers	.003	.047	.371	.758	.005	.050	.319	.666
	Morse Creek	.001	.005	.026	.071	.000	.001	.003	.009
	Dungeness Spit	.005	.034	.212	.492	.834	.999	.999	.999
	Jamestown- Port Williams	.367	.948	.999	.999	.152	.742	.998	.999
	Beckett Point	.003	.024	.218	.492	.001	.003	.027	.095
Fall	Kydaka Beach	.119	.618	.988	.999	.532	.993	.999	.999
	Pillar Point	.015	.049	.305	.583	.043	.274	.811	.978
	Twin Rivers	.011	.038	.138	.284	.016	.062	.230	.444
	Morse Creek	.017	.053	.164	.312	.017	.061	.209	.401
	Dungeness Spit	.012	.102	.512	.844	.048	.413	.955	.999
	Jamestown - Port Williams	.156	.692	.994	.999	.066	.367	.883	.991
	Beckett Point	.000	.001	.006	.021	.000	.003	.023	.081
Winter	Kydaka Beach	.032	.145	.448	.782	.066	.302	.782	.962
	Pillar Point	.071	.198	.484	.719	.156	.375	.722	.900
	Twin Rivers	-	-	-	-	-	-	-	-
	Morse Creek	-	-	-	-	-	-	-	-
	Dungeness Spit	-	-	-	-	-	-	-	-
	Jamestown - Port Williams	.047	.166	.488	.752	.050	.201	.587	.849
	Beckett Point	.012	.051	.203	.413	.057	.076	.245	.444

Decreases of 90% or greater in numbers and biomass should be detectable at virtually every site in summer, fall, and winter; spring again exhibited the most variation but all probabilities exceeded 0.50.

On the whole, changes in numbers would be easier to detect than changes in biomass. The rare occurrence of large individuals in the catches, although not greatly influencing numbers, drastically affects biomass.

The most consistent site in terms of variability of numbers and biomass of the catches between seasons was Twin Rivers. This was reflected in the consistently high probability of detecting changes in all seasons. It is somewhat surprising when one considers the high number of large fish (primarily redtail surfperch and Pacific staghorn sculpin) that occurred in the catches in every season.* The most variable sites were Morse Creek and Dungeness Spit, but their variability was only moderate and only in winter and spring.

4.7.2 Townet

Because of the great variability of numbers and biomass in the townet catches, it would be difficult to detect a decrease of 90% or less in any season at any site. In the most extreme case, over 120,000 Pacific herring were caught in two tows during summer 1977 at Morse Creek, but in other years less than 100 fish were caught per haul. The probability of detecting a change after an oil spill based upon catches of such great variability is very small.

Of all the seasons, spring catches were the most consistent in numbers and biomass; therefore, the probability of detecting a decrease was greater and more consistent than in other seasons. Winter catches were relatively consistent, primarily because of the low number and biomass of fish caught. The fact that many winter tows did not yield any fish resulted in the exclusion of three sites from the analysis--interpretations based on limited data are themselves of limited value. Summer and fall catches were quite variable, particularly at Morse Creek and Beckett Point. Of all the sites, Jamestown-Port Williams exhibited the most within-season consistency throughout the year in both numbers and biomass.

The overall conclusions of the power analysis are: (1) The beach-seine data are better than the townet data for detecting decreases in numbers and biomass of the fish after an oil spill. However, even the change in beach-seine data (numbers or biomass) must in general be 75% or more. (Townet data changes must in general be 95% or more.) (2) With the beach-seine data it is easier to detect changes in numbers than in biomass, and decreases are more difficult to detect in the spring than in other seasons. (However, for townet data, spring is the season when a change is most likely to be detected.)

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*Twin Rivers is a very complex site. The fishes collected there are characteristic of the wide variety of habitats present (rocky intertidal, kelp beds, sand flats) and probably move into the shallow lagoon (sampling area) in search of food and/or refuge. The attractiveness of this site to fishes in summer and fall may be related to the high densities of Crustacea inhabiting the algal fragments and terrestrial plant detritus that accumulate in the lagoon.

4.8 MACROINVERTEBRATES

A total of 191 species of macroinvertebrates was identified from the 1976-1978 nearshore fish collections (Appendix 6.6). There was an increase in the number of species collected in 1977-78. The 1976-77 collections took 83 species by beach seine and 77 species by townet, whereas the beach seine yielded 92 species and the townet 95 species in 1977-78. Decapod crustaceans, amphipods, and gastropod molluscs constituted the most diverse taxa collected, followed by isopods, mysids, polychaetes, euphausiids, and other less common taxa. Abundance data for the macroinvertebrates are included in Appendix 6.7.

Beach-seine samples consisted of demersal and shallow-water epibenthic species, whereas townet samples contained pelagic as well as epibenthic invertebrates. Asteroids, an echinoid, and the majority of the crab species were taken only by the beach seine. Euphausiids, an ophiuroid, chaetognaths, bryozoans, and the majority of the cephalopods were collected exclusively by the townet. Amphipods, isopods, and shrimp were commonly collected by both net types.

Errantiate polychaete worms were collected by both net types--five species by beach seine and ten species by townet. Two nereid species and an unidentified polychaete species were collected by both.

The parasitic isopod Argeia pugettensis was found parasitizing Crangon stylirostris. Other bopyrid isopods were found parasitizing Crangon alaskensis, Heptacarpus pictus, H. taylori, and Pagurus granosimanus. However, the overall amount of parasitism was low and occurred mainly in spring.

The differences in species composition between 1976-77 and 1977-78 (Tables 20a,b) are difficult to interpret as no definite trends are apparent in the data, particularly since in many instances it was not possible to obtain invertebrate samples. In addition, species of gammarid amphipods are not comparable between years because in 1977 only the obvious gammarid amphipod species were recorded (the rest being identified only to family), whereas in 1976 they were more thoroughly identified.

Some of the species that were found both years were not always found at the same sites. Other taxa were much more widely distributed in 1977-78 than in 1976-77, especially shrimp and euphausiids. For example, euphausiids were found almost exclusively in townet samples from Pillar Point in 1976-77 but were found at several locations in 1977-78 (Appendix 6.7).

Species richness in 1976-77 collections generally increased from west to east. Data for 1977-78, however, indicate comparable species richness values at all sites, except Beckett Point, Port Williams, and Whidbey Island where richness was nearly twice that of the other sites (Table 21). These comparisons should not be considered quantitative, however, because of the grouping of the two gear types and the effect of missing data points, especially with the townet. Seasonal species richness values for 1976-77

Table 20a. Number of macroinvertebrate species collected seasonally by beach seine during nearshore fish sampling along the Strait of Juan de Fuca and Whidbey Island, May 1976 - February 1978. NS = not sampled.

	Spring (May)		Summer (August)		Autumn (October)		Winter (Dec. - Feb.)	
Site	1976	1977	1976	1977	1976	1977	76-77	77-78
Kydaka Beach	3	2	3	9	NS	4	6	NS
Twin Rivers	7	5	10	8	1	7	5	5
Morse Creek	15	3	10	8	6	12	13	5
Dungeness Spit	12	3	13	7	9	NS	11	5
Jamestown*	19	NS	8	NS	NS	NS	NS	NS
Port Williams*	NS	17	NS	20	NS	12	NS	15
Beckett Point	35	26	15	13	7	17	22	15
Alexander's Beach	NS	5	NS	10	NS	6	NS	9
West Beach	NS	17	NS	15	NS	NS	NS	3

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*As a result of sampling difficulties at Jamestown in 1977, operations were shifted to Port Williams in 1978.

Table 20b. Number of macroinvertebrate species collected seasonally by townet during nearshore fish sampling along the Strait of Juan de Fuca and Whidbey Island, May 1976 - February 1978. NS = not sampled.

Site	Spring (May) 1976	Spring (May) 1977	Summer (August) 1976	Summer (August) 1977	Autumn (October) 1976	Autumn (October) 1977	Winter (Dec. - Feb.) 76-77	Winter (Dec. - Feb.) 77-78
Kydaka Beach	NS	11	NS	6	NS	12	12	5
Pillar Point	16	24	7	2	NS	12	NS	14
Twin Rivers	5	11	8	4	NS	2	17	NS
Morse Creek	11	19	4	3	NS	16	13	NS
Dungeness Spit	11	16	17	7	NS	11	23	3
Jamestown*	8	NS	10	NS	16	NS	8	NS
Port Williams*	NS	21	NS	9	NS	11	NS	9
Beckett Point	6	10	1	1	NS	5	NS	NS
Alexander's Beach	NS	13	NS	10	NS	14	NS	17
West Beach	NS	17	NS	6	NS	11	NS	17

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*As a result of sampling difficulties at Jamestown in 1977, operations were shifted to Port Williams in 1978.

Table 21. Total number of macroinvertebrate species, according to general taxonomic group, collected during nearshore fish sampling, May 1976 - February 1978, along the Strait of Juan de Fuca and Whidbey Island.

Site	Decapods		Gastropods		Amphipods, isopods		Mysids, euphausiids		Misc. Groups		Total # of species		% Total # of species*	
	76-77	77-78	76-77	77-78	76-77	77-78	76-77	77-78	76-77	77-78	76-77	77-78	76-77	77-78
Kydaka Beach	4	12	0	4	8	6	4	4	3	5	19	31	15	21
Pillar Point	5	9	0	2	5	11	11	5	3	14	24	41	19	28
Twin Rivers	13	13	0	0	9	8	11	5	2	4	35	30	28	20
Morse Creek	14	19	3	1	14	11	8	4	0	6	39	41	31	28
Dungeness Spit	14	14	0	1	20	8	10	4	6	4	50	31	40	20
Jamestown**	26	--	0	--	13	--	6	--	7	--	52	--	41	--
Point Williams**	--	32	--	6	--	13	--	8	--	12	--	71	--	48
Beckett Point	29	29	8	9	12	5	0	5	7	8	56	56	44	38
Alexander Beach	--	18	--	3	--	11	--	6	--	12	--	50	--	34
West Beach	--	16	--	5	--	12	--	13	--	10	--	56	--	38

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*Total species, 1976-77, 126; total species, 1977-78, 148.

**As a result of sampling difficulties at Jamestown in 1977, operations were shifted to Point Williams in 1978.

exhibited a minimum in fall and a maximum in spring. Data for 1977-78 exhibited a maximum in spring and similar numbers of species through the other seasons. There were no consistent seasonal trends in species richness based on habitat, exposure, or geographical location. The spring maximum may be a result of species moving inshore to reproduce, since the greatest number of gravid females was encountered in spring samples.

Although the data are not quantitative, macroinvertebrate abundance and biomass for both beach-seine and townet catches appear to peak in fall and winter. Size frequency distributions pooled by season of collection were plotted for the most common species (Appendix 6.8).

4.9 FOOD WEB RELATIONSHIPS

Stomach contents were analyzed from specimens of nearshore fish collected by beach seine and townet in August 1978 and from intertidal collections during January through August 1978. Sixty-two fish species were included in these analyses (Appendix 6.9). Of the 1,754 stomachs examined, 304 (17.3%) were empty, providing a sample size of 1,450 stomach samples containing food material.

A summary of the prey spectra for fishes collected in 1978 is included in Appendix 6.10; prey spectra for fishes collected in previous years were included in Simenstad et al. (1977), for 1976-77 and in Cross et al. (1978), for 1976-1978. The following discussions of trophic structure, annual and seasonal variation, and diet overlap with documented invertebrate communities are based on the combined results of the three years of investigations.

4.9.1 Functional Feeding Groups of Predominant Nearshore Fishes

Thirty-six species of nearshore fish occurred commonly or abundantly enough along the Strait of Juan de Fuca to be categorized into functional feeding groups (Table 22). The neritic assemblages (those characteristically caught in the townet) are evenly divided among obligate planktivores (i.e., those which exclusively exploit pelagic prey organisms) and facultative planktivores (i.e., those which have prey spectra including both pelagic and epibenthic prey organisms). Although the sampling design for fish collections could not verify such an interpretation, it might be assumed that the obligate planktivores--Pacific herring, Pacific sand lance, and pink salmon--tend to feed throughout the surface waters, while the facultative planktivores--chinook salmon, surf smelt, and longfin smelt--may be more concentrated in shallow water along the shoreline where epibenthic organisms are more available.

We were able to distinguish several feeding groups in the rocky and cobble intertidal, which includes the tidepool habitats characteristic of the rocky headlands (Slip Point, Observatory Point, and Neah Bay) and cobble beaches (Morse Creek, Twin Rivers, and North Beach). In some cases the results from the beach-seine collections made adjacent to cobble beaches (Twin Rivers and Morse Creek), when compared with sites without adjacent cobble, indicate those species which probably originate from the cobble habitat. Fifteen species were evenly divided among obligate epibenthic planktivore, facultative epibenthic planktivore, and facultative benthivore

Table 22. Functional feeding groups of 36 species prominent in the nearshore fish assemblages characterizing the Strait of Juan de Fuca (L = larvae, J = juvenile, A = adult).

Habitat:	Feeding mode:	Predator species: (life history stages)	Principal prey taxa:
Neritic	Obligate planktivore	Pacific herring L,J Pacific sand lance L,J,A; pink salmon J	Calanoid copepods, larvaceans, crustacean and fish larvae, hyperiid amphipods
	Facultative planktivore	Chinook salmon J; surf smelt L,J,A; longfin smelt L,J	Calanoid copepods, larvaceans, crustacean and fish larvae, hyperiid amphipods, shrimp, drift insects, ostracods, harpacticoid copepods, mysids
Gravel, sand/ eelgrass, and mud/eelgrass littoral and shallow sublittoral	Obligate epibenthic planktivore	Chum salmon J; longfin smelt J,A; Pacific tomcod J; walleye pollock J; tube-snout A; sturgeon poacher J, A; shiner perch J,A; striped seaperch J,A; redtail surfperch J,A: sand sole J	Harpacticoid copecods, gammarid amphipods, sphaeromatid isopods, mysids, cumaceans, shrimp, calanoid copepods, tanaids.
	Facultative epibenthic planktivore	Padded sculpin J,A; Pacific staghorn sculpin J,A; roughback sculpin A	Harpacticoid copepods, gammarid amphipods, polychaete annelids, gastropods, crabs, shrimp, mysids
	Facultative benthivore	Rock sole J; English sole J; starry flounder A	Polychaete annelids, gammarid amphipods, isopods, harpacticoid copepods, holothuroideans
	Omnivore	Buffalo sculpin J,A	Algae, gammarid amphipods, polychaete annelids, sphaeromatid isopods
Rocky and cobble littoral	Obligate epibenthic planktivore	Sharpnose sculpin J,A; tidepool sculpin J,A; saddleback sculpin J,A; fluffy sculpin J, A; tidepool snailfish J,A	Harpacticoid copepods, gammarid amphipods, sphaeromatid isopods
	Facultative epibenthic planktivore	Northern clingfish J,A; smoothhead sculpin J,A; rosylip sculpin J,A; silverspotted sculpin J,A; mosshead sculpin J,A	Harpacticoid copepods, gammarid amphipods, polychaete annelids, isopods, gastropods, crabs, shrimp
	Facultative benthivore	High cockscomb J,A; black prickleback J,A; rock prickleback J,A; penpoint gunnel J,A; crescent gunnel J,A	Polychaete annelids, gammarid amphipods, isopods, harpacticoid copepods, incidental algae

feeding groups. No obligate benthivores--i.e., fish preying exclusively on benthic organisms--were identified. In all cases, the utilization of epibenthic crustaceans--harpacticoid copepods, gammarid amphipods, isopods--was common to all feeding groups. Taxonomically, the epibenthic planktivores were sculpin (Cottidae), snailfish (Liparidae), and clingfish (Gobiesocidae), whereas the benthivores were prickleback (Stichaeidae) and gunnel (Pholidae).

Fishes characterizing intertidal and shallow subtidal gravel (sampled by beach seine), sand, and mud habitats have been put in four feeding categories; however, many of these species are found in more than one habitat. The majority (10 of 17) of these fishes can be described as obligate epibenthic planktivores--i.e., those species that feed almost exclusively on crustaceans inhabiting the water column immediately above the bottom. Three other species are also epibenthic planktivores but have more catholic feeding modes which include benthic organisms in their diet. Only three species, all flatfish (Pleuronectidae), were true benthivores and even they fed facultatively since epibenthic crustaceans also appeared as important components in their diets. One species, buffalo sculpin, might be considered an omnivore because of the importance of algae (especially Ulva) in its diet; this phenomenon has been reported in too many other regions to be incidental (Miller et al. 1977; Fresh et al. 1979). As in the intertidal feeding groups, no obligate benthivores were identified.

4.9.2 Variations in Diet Spectra of Predominant Nearshore Fish

When considering the importance of various prey organisms to fishes or when documenting the relative flow of organic carbon through a portion of the marine food web, the researcher should give some thought to the variability in trophic linkages. Such variability involves temporal (seasonal and annual) fluctuations in prey populations as well as spatial (habitat) differences in the relative abundance or productivity of prey populations. An assessment of variability will also indicate the general predictability of prey in a particular habitat. Because of the sampling design used in the MESA baseline studies, most nearshore fish species were not consistently available for stomach analyses over the three years of quarterly sampling. Seasonal, annual, and between-habitat variability in diet was described for some species in Cross et al. (1978). Stomach samples were not retained on a seasonal basis in 1978. Stomach samples from 14 species were retained from August 1978 collections. We have utilized the prey composition (frequency of occurrence, numerical composition, gravimetric composition, and percentage of total IRI) of these coinciding samples to provide indications of variability in the diets of the nearshore fish communities in the Strait of Juan de Fuca. Because of the low sample sizes in some species and the bias associated with a single "point sample" representing a three-month season, these examples should be considered only as illustrations.

The prey composition of the most abundant neritic fish--juvenile Pacific herring--substantiates its grouping with the obligate planktivores (Table 23). There was no instance over the three-year collection at five townet sites in which calanoid copepods were not overwhelmingly the predominant prey organism. Only in one sample--1978, Port Williams--did the percentage of the total IRI drop below 90%, and crustacean larvae became important. Annual dietary overlap, measured by Sanders' Index of Affinity, was over 95% in

Table 23. Prey composition of juvenile Pacific herring during three years of MESA collections for August 1976, 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, % IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
Jamestown/Port Williams	1976 (n=3)				1977 (n=15)				1978 (n=7)			
Calanoid copepods	100.00	99.26	99.66	99.82	6.67	93.75	98.94	96.34	28.57	68.63	60.71	78.55
Harpacticoid copepods	33.33	0.74	0.34	0.18	6.67	1.56	0.35	0.96				
Mysids					6.67	3.13	0.35	1.74				
Gammarid amphipods					6.67	1.56	0.35	0.96				
Crustacean larvae									14.29	31.37	39.29	21.45
Morse Creek	1976 (n=5)				1977 (n=20)				1978 (n=10)			
Calanoid copepods	100.00	99.90	99.89	99.98					100.00	96.00	94.45	97.73
Caridean shrimp	20.00	0.10	0.11	0.02	(All contents unidentifiable)							
Mysids									90.00	1.05	1.13	1.01
Gammarid amphipods									70.00	0.43	0.60	0.37
Crustacean larvae									70.00	0.85	0.17	0.36
Polychaete annelids									10.00	0.37	3.15	0.18
Ostracods									50.00	0.62	0.03	0.17
Cumaceans									50.00	0.37	0.03	0.10
Hyperiid amphipods									50.00	0.16	0.03	0.05
Brachyuran crab larvae									10.00	0.16	0.39	0.08
Pillar Point	1976 (n=4)				1977 (n=20)				1978 (n=10)			
Calanoid copepods	100.00	100.00	100.00	100.00	60.00	100.00	100.00	100.00	80.00	96.27	99.48	98.34
Ostracods									70.00	3.56	0.05	1.58
Euphausiids									20.00	0.10	0.46	0.07
Hyperiid amphipods									10.00	0.02	0.01	<0.00
Crustacean larvae									10.00	0.05	0.01	<0.00
Twin Rivers	1976 (n=8)				1977 (n=25)				1978 (n=10)			
Calanoid copepods	100.00	100.00	100.00	100.00					90.00	95.38	95.65	97.35
Ostracods					(All contents unidentifiable)				100.00	3.95	0.24	2.37
Euphausiids									10.00	0.52	4.09	0.26
Hyperiid amphipods									20.00	0.13	0.02	0.02
Crustacean larvae									10.00	0.02	0.01	<0.00
Kydaka Beach					1977 (n=30)				1978 (n=10)			
Calanoid copepods					100.00	100.00	100.00	100.00	100.00	91.19	99.48	95.51
Ostracods									100.00	8.30	0.28	4.30
Euphausiids									60.00	0.33	0.18	0.15
Hyperiid amphipods									40.00	0.16	0.02	0.04
Unidentified detritus									10.00	0.02	0.04	<0.00

seven of nine comparisons and over 75% in the other two (Table 24). Similarly, dietary overlap was very high in August collections at the five sampling sites (Table 25).

Juvenile chinook salmon was the only salmonid collected consistently at any site over the three years, and then only at Beckett Point. In contrast to the Pacific herring, this facultative neritic planktivore indicated some variability among the prominent prey organisms composing its diet in the three years (Table 26). Sample sizes in 1976 and 1978, however, restrict the applicability of these comparisons. Polychaete annelids and crustacean (brachyuran crab) larvae predominated in the prey spectrum in 1976; dipteran insects, shrimp, and ostracods predominated in 1977; and insects and nereid polychaetes predominated in 1978. Dietary overlap was thus quite low during the three years (Table 24). The surprising consistency in the contribution of drift insects suggests that these food items may be a much more predictable and abundant food resource than has been thought.

As one of many obligate epibenthic planktivores occurring in several habitats along the strait, juvenile Pacific tomcod illustrated considerable annual and between-habitat variability in prey composition (Tables 24, 25, 27). Samples from Morse Creek and Dungeness Spit indicated that mysids and gammarid amphipods were alternately important prey, but when available, calanoid copepods were also preyed on. Annual prey overlap values, therefore, were less than 50% and between-habitat overlap values were less than 15%. The August 1978 collections at these two sites and at Beckett Point indicated that different prey may constitute the major dietary item in different habitats at the same time. Despite the importance of mysids and gammarid amphipods at Dungeness Spit and Morse Creek, respectively, hippolytid shrimp completely dominated the prey spectrum at Beckett Point. As will be pointed out later, hippolytid shrimp are one of the most important epibenthic organisms available to fish at Beckett Point (Simenstad et al. 1980.).

Northern clingfish were one of the most common species in the intertidal collections, especially in cobble habitats. Sample sizes from August collections in specific habitats were not large enough to provide between-habitat comparisons. Prey spectra from the combined stomach samples in each year indicated some variability among the three most important prey taxa--sphaeromatid isopods, acmaeid limpets, and gammarid amphipods--which resulted in low indices of dietary overlap (Tables 24, 28). Despite the greater potential similarity between the August intertidal samples as opposed to combined annual samples, the dietary overlap was actually 10% lower between the August samples, reflecting the almost complete absence of acmaeid limpets in the diet in 1978.

Rosylip sculpin were present in comparable collections for the last two years of the study. Unlike northern clingfish, rosylip sculpin had very similar dietary compositions in the two years because of the apparent specificity toward gammarid amphipods (Table 29). Although the dietary overlap was almost 85% in the two years' samples, the overlap in the August collections was appreciably less (Table 24); the low sample size for August 1978 may have contributed to this difference.

Table 24. Year-to-year overlap (Sanders' Index of Affinity) between the diet compositions (pooled over year) of twelve prominent nearshore fish species along the Strait of Juan de Fuca. Unless otherwise noted, all samples are from August collections, 1976, 1977, 1978.

	1976 vs 1977	1977 vs 1978	1976 vs 1978
Pacific herring			
Jamestown - Port Williams	96.52	78.53	78.53
Morse Creek	--	--	97.73
Pillar Point	100.00	98.34	98.34
Twin Rivers	--	--	97.35
Kydaka Beach	--	95.51	--
($\bar{x}$)	(98.26)	(90.79)	(92.99)
Chinook salmon			
Beckett Point	6.90	27.97	4.93
Pacific tomcod			
Morse Creek	15.80	48.67	41.59
Dungeness Spit	--	--	9.73
Northern clingfish			
All tidepool	66.32	40.95	41.69
August tidepool	--	33.71	--
Rosylip sculpin			
All tidepool	--	84.20	--
August tidepool	--	63.89	--
Silverspotted sculpin			
Twin Rivers	84.61	--	--
Sharpnose sculpin			
All tidepool	--	86.21	--
August tidepool	--	45.98	--
Staghorn sculpin			
Beckett Point	12.80	15.45	2.24
Morse Creek	37.64	40.59	4.25
Jamestown - Port Williams	20.25	63.27	13.48
Twin Rivers	34.54	16.34	14.61
($\bar{x}$)	(26.06)	(26.06)	(8.65)
Tidepool sculpin			
All tidepool	82.39	49.38	39.94
August tidepool	--	24.96	--
Jamestown - Port Williams, August	--	13.84	--
($\bar{x}$)		(29.39)	
Redtail surfperch			
Twin Rivers	78.73	67.02	54.35

Table 24. (Contd.)

	1976 vs 1977	1977 vs 1978	1976 vs 1978
High cockscomb			
All tidepool	72.92	35.11	34.79
August tidepool	--	23.20	--
English sole			
Jamestown - Port Williams	47.34	54.37	78.26
Twin Rivers	32.65	74.42	7.13
Morse Creek	27.53	57.89	53.82
Dungeness Spit	19.75	40.59	19.96
Kydaka Beach	55.49	--	--
($\bar{x}$)	(36.55)	(56.82)	(39.79)
Starry flounder			
Kydaka Beach	--	2.22	--
Sand sole			
Dungeness Spit	20.40	11.12	78.75
Morse Creek	--	31.63	--
Kydaka Beach	59.23	2.24	26.67
Twin Rivers	83.92	92.84	92.10
($\bar{x}$)	(54.52)	(34.46)	(65.84)

Table 25. Geographical Overlap (Sanders' Index of Affinity) between the diets of five nearshore fish species at sampling sites along the Strait of Juan de Fuca in August 1976, 1977, and 1978.

Pacific herring, juvenile

		Morse Creek	Pillar Point	Twin Rivers	Kydaka Beach
Jamestown - Port Williams	1976	99.82	99.82	99.82	--
	1977	--	96.34	--	96.34
	1978	78.91	78.55	78.55	78.55
Morse Creek	1976		99.98	99.98	--
	--				
	1978		97.90	97.54	95.72
Pillar Point	1976			100.00	--
	1977				100.00
	1978			99.00	97.16
Twin Rivers	--				
	--				
	1978				98.05
	($\bar{x}$)	(89.37)	(94.52)	(95.82)	(94.30)

Pacific tomcod, juvenile

		Morse Creek	Dungeness Spit
Beckett Point	1978	0.31	0.85
Morse Creek	1976		11.86
	1978		13.66
	($\bar{x}$)		(8.79)

Table 25. (Contd.)

Staghorn sculpin

		Morse Creek	Jamestown Point Williams	Twin Rivers
Beckett Point	1976	4.39	27.20	23.42
	1977	23.88	50.53	18.25
	1978	21.61	19.10	24.96
Morse Creek	1976		7.69	0.00
	1977		23.92	31.78
	1978		2.25	11.25
Jamestown - Port Williams	1976			13.49
	1977			16.75
	1978			7.90
	($\bar{x}$)	(16.63)	(21.78)	(16.42)

English sole, juvenile

		Twin Rivers	Morse Creek	Dungeness Spit	Kydaka Beach
Jamestown-Port Williams	1976	31.57	9.16	8.22	7.81
	1977	4.98	25.56	34.89	15.93
	1978	7.13	32.82	2.23	--
Twin Rivers	1976		69.99	51.93	51.65
	1977		32.70	11.02	33.05
	1978		7.13	58.57	--
Morse Creek	1976			49.95	52.08
	1977			47.41	58.39
	1978			1.99	--
Dungeness Spit	1976				61.30
	1977				56.98
	1978				--
	($\bar{x}$)	(14.56)	(29.56)	(29.58)	(42.15)

Table 25. (Contd.)

		Sand sole, juvenile		
		Morse Creek	Twin Rivers	Kydaka Beach
Dungeness Spit	1976	--	73.13	40.40
	1977	64.64	24.64	10.68
	1978	9.03	86.84	21.36
Morse Creek	1977		44.63	17.64
	1978		50.17	53.90
Twin Rivers	1976			42.19
	1977			6.79
	1978			43.97
	($\bar{x}$)	(36.84)	(55.88)	(29.62)

Table 27. Prey composition of juvenile Pacific tomcod during three years of MESA collections, August 1976, 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, % IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
Beckett Point									1978 (n=19)			
Hippolytid shrimp									100.00	67.42	98.63	98.94
Tanaids									5.26	0.76	0.01	0.02
Gammarid amphipods									5.26	0.76	0.05	0.03
Polychaete annelids									5.26	30.30	0.01	0.95
Crangonid shrimp									5.26	0.76	1.30	0.06
Morse Creek	1976 (n=6)				1977 (n=7)				1978 (n=10)			
Mysids	66.67	9.65	75.10	48.26	14.29	3.85	18.83	4.52				
Calanoid copepods	50.00	83.11	11.28	40.31					30.00	66.67	0.28	30.16
Gammarid amphipods	66.67	6.58	13.23	11.28	42.86	88.46	62.34	90.19	60.00	11.67	42.36	48.67
Cumaceans	16.67	0.66	0.39	0.15					40.00	6.67	11.97	11.19
Hippolytid shrimp					14.29	7.69	18.83	5.29				
Gammaridae									10.00	1.67	23.94	3.85
Harpacticoid copepods									20.00	5.83	0.18	1.81
Caridean shrimp									10.00	0.83	9.21	1.51
Atylidae									10.00	0.83	3.68	0.68
Eusiridae									10.00	1.67	2.76	6.67
Tanaids									10.00	0.83	1.84	0.40
Ostracods									10.00	0.83	1.84	0.40
Polychaete annelids									10.00	0.83	0.92	0.26
Insects									10.00	0.83	0.92	0.26
Brachyrhynchan crabs									10.00	0.83	0.09	0.14
Dungeness Spit	1976 (n=15)								1978 (n=11)			
Gammarid amphipods	86.67	78.25	38.79	85.81					81.92	13.30	2.23	9.26
Sphaeromatid isopods	53.33	5.52	8.14	6.16								
Cumaceans	46.67	7.14	3.33	4.14					9.09	0.28	0.02	0.02
Molluscs	6.67	0.32	39.97	2.27								
Idoteid isopods	20.00	0.97	3.21	0.71								
Mysids	6.67	3.57	4.07	0.43					90.91	78.95	52.06	86.85
Caprellid amphipods	6.67	0.32	1.50	0.10					9.09	0.28	0.02	0.02
Ostracods	13.33	0.65	0.23	0.10								
Caridean shrimp	13.33	0.65	0.21	0.10								
Oedocerotidae	6.67	0.97	0.11	0.06								
Brachyrhynchan crab larv.	6.67	0.65	0.32	0.05								
Harpacticoid copepods	6.67	0.65	0.01	0.04								
Unid. debris	6.67	0.32	0.11	0.02								
Pleuronectidae									9.09	0.28	32.31	2.16
Hippolytid shrimp									9.09	0.55	11.86	0.82
Eusiridae									18.18	3.88	0.13	0.53
Phoxocephalidae									18.18	1.11	0.04	0.15
Callianassid shrimp									9.09	0.28	1.23	0.10
Oedicerotidae									9.09	0.55	0.04	0.04
Valviferan isopods									9.09	0.28	0.06	0.02
Cancrid crabs									9.09	0.28	0.02	0.02

Table 28. Prey composition of northern clingfish during three years of MESA collections, August 1976, 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, % IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
All tidepool	1976 (n=118)				1977 (n=102)				1978 (n=47)			
Sphaeromatid isopods	36.44	32.47	21.80	46.36	33.33	16.08	12.92	21.32	25.53	2.07	6.40	6.90
Acmaeid limpets	25.42	19.32	23.43	25.48	28.43	11.54	24.80	22.79	40.43	5.89	50.69	72.98
Gammarid amphipods	33.05	20.13	3.90	18.62	48.04	37.76	5.80	46.16	40.43	3.26	1.97	6.75
Unid. gastropods	15.25	6.82	2.40	3.30	7.84	2.27	0.35	0.45				
Idoteid isopods	6.78	1.62	14.93	2.63	10.78	2.62	17.93	4.89	4.26	0.24	17.28	2.38
Unid. debris	6.78	1.46	6.83	1.32	3.92	1.22	1.02	0.19				
Ostracods	8.47	3.90	0.04	0.78	3.92	1.22	0.01	0.11	6.38	0.56	0.01	0.12
Fishes	2.54	0.49	5.59	0.36	1.96	0.35	3.07	0.15				
Ischnochitonidae	1.69	0.32	4.83	0.20	0.98	0.17	1.29	0.03				
Hippolytid shrimp	0.85	0.16	2.94	0.06					2.13	0.08	2.16	0.15
Unid. isopods	1.69	1.14	0.08	0.05								
Barnacle cirri	0.85	1.46	0.01	0.03	5.88	1.75	0.03	0.23				
Harpacticoid copepods					4.90	11.36	0.03	1.23	14.89	1.83	0.02	0.88
Polychaete annelids					7.84	1.40	2.02	0.59	2.13	79.62	9.03	6.02
Grapsid crabs					1.96	0.35	9.36	0.42	2.13	0.08	1.47	0.11
Cancrid crabs					3.92	0.70	8.02	0.38				
Sabellarid polychaetes					3.92	2.27	0.12	0.21	10.64	3.11	0.37	1.18
Littorine snails					3.92	1.40	0.39	0.15	8.51	0.40	3.48	1.05
Pagurid crabs					1.96	0.35	1.59	0.08	6.38	0.32	4.44	0.97
August tidepool					1977 (n=13)				1978 (n=10)			
Acmaeid limpets					53.85	23.75	61.26	60.38	12.50	2.04	0.01	0.55
Sphaeromatid isopods					30.77	30.00	12.49	17.25	25.00	16.33	25.20	22.22
Gammarid amphipods					46.15	20.00	2.27	13.56	37.50	26.53	2.83	23.56
Barnacle cirri					30.77	8.75	0.02	3.56				
Idoteid isopods					15.38	3.75	6.57	2.09	12.50	4.08	63.45	18.07
Bangiales					7.69	1.25	10.34	1.18				
Mopaliidae					7.69	1.25	4.04	0.54				
Crustacean larvae					15.38	2.50	0.38	0.29				
Mesogastropoda					7.69	2.50	0.11	0.26	12.50	6.12	1.33	1.99
Polychaete annelids					7.69	1.25	0.11	0.26				
Balanidae					7.69	1.25	0.65	0.19				
Nemerteans					7.69	1.25	0.16	0.14				
Harpacticoid copepods									37.50	36.73	0.04	29.52
Valviferan isopods									12.50	4.08	3.85	2.12
Ulotrichales									12.50	2.04	1.78	1.02
Pagurid crabs									12.50	2.04	1.48	0.94

Table 29. Prey composition of rosylip sculpin during two years of MESA collections, August 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, % IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
All tidepool	1977 (n=116)				1978 (n=42)			
Gammarid amphipods	63.79	65.27	11.71	75.49	50.00	55.86	19.71	71.17
Sphaeromatic isopods	32.76	11.98	7.27	9.69	16.67	11.72	12.34	7.55
Idoteid isopods	15.52	3.14	28.53	7.56	2.38	0.69	6.46	0.32
Polychaete annelids	15.52	2.84	18.30	5.04	21.43	14.48	20.14	13.98
Pagurid crabs	8.62	1.65	4.71	0.84				
Unidentified decapods	2.59	0.90	7.28	0.33				
Oxyrhynchan crabs	4.31	0.90	2.40	0.22				
Caridean shrimp	3.45	0.90	2.49	0.18				
Hippolytid shrimp	3.45	0.60	2.52	0.17				
Mysids	0.86	4.34	4.49	0.12	2.38	3.45	5.13	0.38
Cumaceans	3.45	1.20	0.02	0.06				
Nereid polychaetes	1.72	0.30	1.96	0.06				
Hydroids	0.86	0.15	2.78	0.04				
Pinnotherid crabs	0.86	0.15	1.60	0.02				
Gnathostomata	0.86	0.15	1.68	0.02				
Brachyrhynchan crabs					9.52	2.76	27.08	5.35
Unid. flabelliferan isopods					7.14	2.07	0.75	0.38
Gammaridae					4.76	1.38	0.41	0.16
Fish larvae					2.38	3.45	6.79	0.46
August tidepool	1977 (n=107)				1978 (n=12)			
Gammarid amphipods	65.42	16.73	14.80	63.30	66.67	66.67	22.00	70.77
Sphaeromatid isopods	30.84	7.85	21.70	27.97				
Idoteid isopods	5.61	0.60	13.77	2.47				
Crustacean larvae	0.93	69.70	0.43	2.01				
Cottidae	2.80	0.14	10.98	0.96				
Caridean shrimp	2.80	0.14	9.77	0.85				
Unidentified debris, sand, and algae	3.74	0.19	4.69	0.56				
Polychaete annelids	5.61	0.37	2.06	0.42	16.67	8.33	6.75	3.01
Crangonid shrimp	1.87	0.09	5.63	0.33				
Gammaridae	3.74	0.37	1.12	0.17	16.67	5.56	1.09	1.33
Mysids	2.80	0.93	6.14	0.27				
Pagurid crabs	1.87	0.09	2.34	0.14				
Fishes	1.87	0.28	1.56	0.11				
Unidentified decapods	1.87	0.09	1.55	0.09				
Oxyrhynchan crabs	1.87	0.09	1.39	0.08				
Unidentified flabelliferan isopods					16.67	5.56	0.44	1.20
Brachyuran crab larvae					8.33	2.78	1.09	0.39
Tanaids					8.33	2.78	0.02	0.28

The single comparison available for silverspotted sculpin--August 1976 and 1977 samples from Twin Rivers--illustrated high dietary overlap (almost 85%) due to the relatively constant proportions of mysids and gammarid amphipods (Tables 24, 30).

Variability in the prey composition documented for sharpnose sculpin in intertidal collections showed a trend consistent with that shown by rosylip sculpin--i.e., high dietary overlap (85%) for the combined annual samples but considerably less for the August samples (Tables 24, 31) because the principal prey taxa, gammarid amphipods and sphaeromatid isopods, were reversed in importance.

Staghorn sculpin is one of the most widely distributed and commonly encountered nearshore fishes along the Strait of Juan de Fuca. The important prey taxa were seldom consistent either between years (Tables 24, 32) or between habitats (Table 25) and dietary overlap values were generally less than 50%. The highest annual dietary overlap values, though not considered significant, were in the 1977 and 1978 samples at Jamestown-Port Williams. The opportunistic use of patchily distributed, large prey organisms--fishes (seaperch, sand lance, flatfish), shrimp, crabs, and mysids--is probably the reason for such high variability. Low sample sizes may have biased the estimate of this variability.

Tidepool sculpin, a common sculpin in all intertidal and some beach-seine collections, ate mostly epibenthic crustaceans. Prey taxa often varied between samples (Table 33); for example, while gammarid amphipods were equally important in the combined tidepool samples for 1976 and 1977, harpacticoid copepods contributed more to the total prey composition in 1978. Whether this reflects a general increase in availability of harpacticoid copepods over the three years or a bias of the sampling design cannot be answered without quantitative samples of epibenthic zooplankton during these years. The importance of harpacticoid copepods is even more pronounced in the August 1978 tidepool collections and 1978 Port Williams beach-seine collection. In both cases the increased importance of harpacticoid copepods resulted in even lower diet overlap values (Table 24) than for the combined annual tidepool collections.

Redtail surfperch were consistently caught over the three years only at Twin Rivers. While gammarid amphipods dominated the prey composition in all three years, their relative importance declined between 1976-77 and 1978 with increased contribution by flabelliferan isopods (Table 34). It is impossible to determine whether or not this increased utilization reflects actual increased availability of flabelliferan isopods.

High cockscomb were chosen as representative of the facultative benthivores of the intertidal rocky headlands and cobble habitats. While prey compositions for combined intertidal collections in 1976 and 1977 were similar (Tables 24, 35), 1978 collections were less so because of the decreased representation of nemerteans and increased contribution of polychaetes. This was further examplified in the comparison between 1977 and 1978 August tidepool collections which had a dietary overlap value of 23.20%. Similar to the diet of tidepool sculpin, harpacticoids were more important in 1978 than in 1976 or 1977.

Table 30. Prey composition of silverspotted sculpin during two years of MESA collections, August 1976, 1977. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, % IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
Twin Rivers	1976 (n=10)				1977 (n=7)			
Mysids	80.00	68.03	48.57	76.29	85.71	53.85	64.31	68.41
Gammarid amphipods	80.00	13.93	10.82	16.20	57.14	46.15	35.69	31.59
Idoteid isopods	20.00	1.64	1.67	0.54				
Caridean shrimp	20.00	14.75	15.08	4.88				
Crangonid shrimp	10.00	1.64	23.87	2.09				

Table 31. Prey composition of sharpnose sculpin during two years of MESA collections, August 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, % IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
All tidepool	1977 (n=61)				1978 (n=26)			
Gammarid amphipods	60.66	38.15	41.30	52.29	57.69	30.94	44.46	56.96
Sphaeromatid isopods	52.46	23.99	45.53	39.57	42.31	17.27	31.97	27.28
Dipteran insects	22.95	9.25	3.78	3.24	23.08	15.83	0.95	5.07
Harpacticoid copepods	16.39	20.23	0.84	3.75	15.38	12.95	0.12	2.63
Idoteid isopods	9.84	2.02	5.20	0.77	15.38	19.42	18.71	7.68
Cumaceans	6.56	2.02	0.09	0.15				
Asellotan isopods	4.92	1.16	0.50	0.09				
Polychaete annelids	3.28	0.58	1.13	0.06				
Ostracods	1.64	1.73	0.02	0.03				
Unidentified gastropods					3.85	0.72	3.17	0.20
August tidepool	1977 (n=23)				1978 (n=9)			
Gammarid amphipods	56.52	68.50	79.98	77.68	22.22	25.00	1.90	23.71
Sphaeromatid isopods	47.83	30.71	19.60	22.27	11.11	12.50	95.24	47.48
Harpacticoid copepods					11.11	37.50	0.95	16.95
Ostracods					11.11	12.50	0.95	5.93
Unidentified debris, sand, and algae					11.11	12.50	0.95	5.93

Table 32. Prey composition of staghorn sculpin during three years of MESA collections, August 1976, 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, %IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
Beckett Point	1976 (n=10)				1977 (n=14)				1978 (n=11)			
Fishes	30.00	97.73	33.34	77.22	7.14	1.32	12.22	2.33				
Atelecyclid crabs	30.00	0.14	15.42	9.17	14.29	2.63	7.36	3.43				
Crangonid shrimp	30.00	0.19	4.17	2.57	28.57	9.21	2.83	8.28	9.09	0.74	0.50	0.19
Hippolytid shrimp	30.00	0.48	2.41	1.70	28.57	5.26	0.73	4.12	9.09	1.47	0.09	0.24
Pandalid shrimp	10.00	0.39	13.04	2.64	7.14	1.32	4.26	0.96				
Pleocyemata	10.00	0.05	11.89	2.34								
Grapsid crabs	10.00	0.10	6.94	1.38								
Perciformes	10.00	0.05	5.05	1.00								
Cancrid crabs	10.00	0.05	4.73	0.94	14.29	6.58	14.09	7.10	18.18	2.94	60.76	19.23
Caridean shrimp	20.00	0.19	1.21	0.55	7.14	3.95	0.88	0.83	27.27	2.94	0.24	1.44
Unid. detritus	10.00	0.43	1.20	0.32	7.14	2.63	1.44	0.70	18.18	5.88	0.24	1.85
Flabelliferan isopods	10.00	0.05	0.57	0.12								
Nematodes	10.00	0.10	0.02	0.02								
Gammarid amphipods					50.00	30.26	2.17	39.01	9.09	0.74	0.00	0.11
Embiotocid fishes					14.29	5.26	49.09	18.68				
Brachyrhynchan crabs					21.43	7.89	2.11	5.16	18.18	6.62	0.14	2.04
Mysids					21.43	5.26	0.08	2.76				
Tanaids					21.43	5.26	0.01	2.72	72.73	50.00	0.09	60.48
Potamogetonaceae					7.14	3.95	0.38	0.74	9.09	13.24	16.95	4.56
Bivalves					7.14	1.32	0.43	0.30	36.36	9.56	0.10	5.83
Majid crabs					7.14	1.32	0.15	0.25	9.09	0.74	6.03	1.02
Polychaete annelids					7.14	1.32	0.00	0.23	9.09	3.68	0.22	0.58
Pagurid crabs									9.09	0.74	0.03	0.12
Gadidae									9.09	0.74	14.60	2.31
Ulotrichales					14.29	5.26	1.75	2.41				
Morse Creek	1976 (n=5)				1977 (n=9)				1978 (n=8)			
Crangonid shrimp	40.00	44.00	70.84	65.57	22.22	8.11	21.89	14.17	25.00	3.33	1.45	2.19
Flabelliferan isopods	40.00	20.00	5.05	14.30	33.33	24.32	5.09	20.84				
Gammarid amphipods	40.00	8.00	2.40	5.94	22.22	13.51	0.44	6.59				
Hippolytid shrimp	20.00	4.00	11.06	4.30								
Mysids	20.00	12.00	0.18	3.48								
Polychaete annelids	20.00	8.00	3.31	3.23	22.22	5.41	3.97	4.43	12.50	1.67	0.10	0.40
Valviferan isopods	20.00	4.00	7.15	3.18					25.00	3.33	0.30	1.66
Pleuronectidae					22.22	8.11	36.55	21.10	25.00	10.00	46.49	25.83
Fishes					22.22	5.41	20.67	12.32	37.50	5.00	12.35	11.90

Table 32. (Contd.)

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
Twin Rivers	1976 (n=3)				1977 (n=7)				1978 (n=4)			
Unidentified detritus	66.67	50.00	0.77	33.73	42.86	20.83	5.12	20.46	25.00	22.22	0.56	7.37
Pleuronectiformes	66.67	20.00	30.30	33.41								
Fishes	33.33	20.00	48.86	22.87	42.86	16.67	33.77	39.76	25.00	5.56	16.82	7.24
Brachyuran crabs	33.33	10.00	20.07	9.99								
Brachyrhynchan crabs					28.57	12.50	4.98	9.18				
Cottidae					14.29	4.17	28.97	8.71				
Cancrid crabs					14.29	8.33	18.32	7.00				
Polychaete annelids					14.29	20.83	4.42	6.64				
Chlorophyta					28.57	8.33	1.95	5.40				
Crangonid shrimp					14.29	4.17	2.44	1.73	50.00	11.11	1.62	8.24
Flabelliferan isopods					14.29	4.17	0.03	1.10				
Embiotocidae									50.00	16.67	79.52	62.27
Potamogetonaceae									25.00	33.33	1.46	11.26
Gammarid amphipods									25.00	11.11	0.03	3.61
Unidentified algae					22.22	13.51	1.72	7.20				
Idoteid isopods					22.22	10.81	3.87	6.94				
Cancrid crabs					22.22	5.41	5.18	5.00	37.50	13.33	10.99	16.68
Caridean shrimp					11.11	2.70	0.49	0.75				
Unidentified isopods					11.11	2.70	0.12	0.67				
Brachyuran crabs									25.00	31.67	11.56	19.77
Ulotrichales									50.00	15.00	0.30	14.00
Brachyrhynchan crabs									12.50	1.67	12.56	3.25
Potamogetonaceae									12.50	6.67	1.30	1.82
Pandalid shrimp									12.50	1.67	2.05	0.85
Majid crabs									12.50	1.67	0.50	0.50
Mysids									12.50	1.67	0.03	0.39
Wood									12.50	1.67	0.03	0.39
Bivalves									12.50	1.67	0.01	0.38
Jamestown-Port Williams	1976 (n=6)				1977 (n=17)				1978 (n=15)			
Polychaete annelids	50.00	55.26	13.61	52.15	11.76	0.89	4.08	0.65	20.00	0.86	4.28	1.00
Callianassid shrimp	16.67	2.63	49.13	13.06								
Unidentified decapods	33.33	5.26	14.24	9.84	5.88	0.18	1.72	0.12				
Unidentified detritus	33.33	13.16	3.13	8.22	47.06	3.56	7.34	5.69	33.33	9.77	2.11	3.88
Fishes	16.67	2.63	18.26	5.27	17.65	0.53	49.92	9.87				
Gammarid amphipods	33.33	7.89	0.94	4.46	88.24	39.86	5.72	44.60	73.33	18.39	12.63	22.29
Tanaids	33.33	7.89	0.06	4.01	29.41	20.28	0.41	6.75	46.67	24.71	6.04	14.06
Bivalves	33.33	5.26	0.63	2.98	11.76	0.36	0.01	0.05	13.33	0.57	0.45	0.13
Mysids					76.47	30.60	2.61	28.17	80.00	39.94	22.13	48.66
Pandalid shrimp					11.76	0.36	16.40	2.19				
Dipterans									6.67	0.29	0.25	0.04
Hippolytid shrimp					17.65	0.71	3.13	0.75	26.67	2.30	25.35	7.22
Crangonid shrimp					11.76	0.36	5.18	0.72	6.67	0.29	6.04	0.41
Cancrid crabs					5.88	0.89	2.44	0.22	6.67	0.29	13.73	0.92
Flabelliferan isopods					11.76	0.36	0.44	0.10	20.00	1.15	4.07	1.02
Caridean shrimp					5.88	0.71	0.46	0.08				
Pinnotherid crabs					5.88	0.18	0.10	0.02				
Caprellid amphipods					5.88	0.18	0.05	0.01				
Ostracods									13.33	0.57	0.50	0.14
Brachyuran crabs									6.67	0.86	2.41	0.21

Table 33. Prey composition of tidepool sculpin during three years of MESA collections for August 1976, 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, %IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
All tidepool	1976 (n=230)				1977 (n=223)				1978 (n=137)			
Gammarid amphipods	53.04	23.81	21.98	48.44	51.12	27.29	19.96	48.95	45.99	6.25	12.06	15.62
Sphaeronatid isopods	37.39	14.48	32.13	34.76	36.77	10.16	21.63	23.69	27.74	4.29	20.40	12.71
Barnacle cirri	18.26	19.44	2.31	7.92	17.04	6.74	1.06	2.69	13.87	3.88	11.87	4.05
Harpacticoid copepods	15.22	15.67	0.58	4.93	20.18	34.46	0.70	14.37	42.34	72.21	5.00	60.66
Polychaete annelids	7.83	2.78	9.48	1.91	18.83	2.48	15.51	6.87	12.41	1.04	12.00	3.00
Crustacean larvae	1.74	12.25	0.42	0.44	2.24	0.33	1.87	0.10				
Idoteid isopods	2.17	0.30	7.85	0.35								
Dipteran insects	7.83	1.24	0.32	0.24	9.87	2.48	0.27	0.55	10.95	2.56	0.52	0.63
Ostracods	5.22	1.54	0.14	0.17					13.14	2.24	0.12	0.38
Pagurid crabs	2.17	0.25	3.64	0.17	3.59	0.56	10.04	0.77	2.19	0.12	2.72	0.12
Unidentified insects	4.35	1.19	0.27	0.13	4.48	2.01	0.49	0.23	6.57	0.76	0.17	0.11
Nemerteans	2.61	0.79	1.71	0.13								
Unidentified debris, sand & algae	1.30	2.43	0.89	0.09	3.14	0.37	2.65	0.19	2.92	0.36	1.06	0.08
Acmaeid limpets	0.87	0.64	1.40	0.04								
Cottidae	0.43	0.05	4.49	0.04								
Turbellarians	0.87	0.15	1.75	0.03								
Caridean shrimp	0.43	0.05	1.82	0.02								
Nudibranchs	0.43	0.15	2.08	0.02								
Mysids					3.14	1.54	6.66	0.52				
Grapsid crabs					2.24	0.42	2.34	0.13	2.92	0.16	2.45	0.14
Fishes					2.24	1.59	1.12	0.12				
Cumaceans					1.79	1.12	0.04	0.04				
Callianassid shrimp					0.90	0.09	4.10	0.08				
Chitons					0.90	0.09	1.28	0.02				
Glyceridae					0.90	0.23	3.05	0.06				
Asselotan isopods									8.03	0.72	0.79	0.23
Coleoptera									5.84	0.56	0.83	0.15
Gammaridae									5.84	0.72	1.11	0.20
Hyalidae									5.11	0.64	2.77	0.32
Brachyrhynchan crab, juv.									4.38	0.64	9.46	0.82
Isaeidae									2.19	0.12	1.61	0.07
Hippolytid shrimp									1.46	0.08	1.94	0.05
Fishes									1.46	0.08	2.77	0.08
Archaeogastropods									1.46	0.08	4.61	0.13
Ampithodae									0.73	0.04	1.06	0.01
August tidepool					1977 (n=39)				1978 (n=73)			
Sphaeronatid isopods					41.03	21.77	34.14	44.83	10.96	0.89	4.36	1.23
Gammarid amphipods					43.59	29.03	4.50	28.56	45.21	5.40	8.01	10.38
Pagurid crabs					12.82	3.63	41.94	11.42				
Harpacticoid copepods					17.95	26.21	0.29	9.29	41.10	74.90	3.09	68.40
Barnacle cirri					15.38	12.10	0.53	3.79	17.81	3.21	23.83	10.28
Polychaete annelids					7.69	1.61	6.50	1.22	4.11	0.21	2.91	0.27
Callianassid shrimp					2.56	0.40	7.48	0.39				
Terebellidae					2.56	0.40	2.08	0.12				
Dipteran insects									16.44	4.10	1.06	1.81
Ostracods									13.70	2.67	0.10	0.81
Asselotan isopods									12.33	1.03	1.37	0.63
Gammaridae									10.96	1.23	2.32	0.83
Coleoptera									10.96	0.96	1.74	0.63
Hyalidae									9.59	1.09	5.81	1.41
Asselotan isopods									5.48	0.96	0.97	0.23
Isaeidae									4.11	0.21	3.39	0.32
Archaeogastropods									2.74	0.14	9.68	0.57
Brachyrhynchan crab, juv.									4.11	0.27	15.49	1.38
Brachyuran crab, juv.									5.48	0.27	1.36	0.19
Hippolytid shrimp									1.37	0.07	2.90	0.09
Acmaeid limpets									1.37	0.14	1.94	0.06
Ampithodae									1.37	0.07	2.23	0.07
Fishes									1.37	0.07	2.71	0.08
Unidentified debris, sand & algae									1.37	0.07	1.55	0.05
Port Williams					1977 (n=11)				1978 (n=29)			
Gammarid amphipods					81.82	80.33	82.43	93.72	37.93	4.00	12.20	9.96
Mysids					45.45	9.84	3.74	4.34	20.69	2.19	5.68	2.64
Polychaete annelids					9.09	1.64	13.25	0.95	10.34	0.39	10.66	1.85
Tanaids					18.18	6.56	0.05	0.85	10.34	0.39	0.48	0.15
Sphaeromatid isopods					9.09	1.64	0.53	0.14	3.45	0.13	2.39	0.14
Harpacticoid copepods									44.83	88.19	26.34	81.78
Hippolytid shrimp									3.45	0.13	30.45	1.71
Calanoid copepods									6.90	4.65	3.28	0.89
Unidentified debris									6.90	0.77	4.57	0.60
Valviferan isopods									3.45	0.13	1.74	0.10
Isaeidae									3.45	0.13	1.09	0.07

Table 34. Prey composition of redtail surfperch during three years of MESA collection, August 1976, 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, %IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
Twin Rivers	1976 (n=10)				1977 (n=10)				1978 (n=13)			
Gammarid amphipods	90.00	71.27	81.15	78.15	55.00	75.32	86.81	86.63	84.62	42.73	39.55	53.83
Mysids	90.00	24.04	14.33	19.67	10.00	1.30	0.65	0.21	7.69	0.91	1.37	0.14
Hyperiid amphipods	10.00	1.49	0.71	0.13								
Flabelliferan isopods	30.00	0.34	0.21	0.09	40.00	16.88	11.10	11.96	69.23	29.09	48.15	41.35
Natantian shrimp	10.00	0.06	0.08	0.04								
Fish	10.00	0.06	0.06	0.01								
Idoteid isopods					20.00	2.60	0.72	0.71	30.77	6.36	4.66	2.62
Polychaete annelids					10.00	1.30	0.65	0.21	7.69	0.91	0.76	0.10
Talitridae									7.69	10.00	4.04	0.84
Dipteran insects									23.08	2.73	1.07	0.68
Ulotrichales									7.69	1.82	0.01	0.11
Atylidae									7.69	0.91	0.08	0.06
Unidentified algae	60.00	2.73	2.86	1.98	10.00	3.00	0.07	0.26	7.69	4.55	0.31	0.29

Table 35. Prey composition of high cockscomb during three years of MESA collections, August 1976, 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, %IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
All tidepool	1976 (n=118)				1977 (n=155)				1978 (n=53)			
Nemerteans	42.37	27.02	26.03	52.81	27.74	5.13	25.18	36.07	7.55	0.39	6.26	1.23
Polychaete annelids	22.88	10.62	27.64	20.57	21.94	5.34	16.91	19.77	32.08	10.11	31.48	46.61
Gammarid amphipods	30.51	16.17	7.05	16.64	34.19	16.32	6.52	31.64	28.30	2.07	7.50	9.47
Unidentified debris, sand & algae	11.86	5.31	3.99	2.59	3.23	0.51	1.14	0.22	15.09	1.10	19.79	11.02
Rhodophyta	9.32	4.85	5.24	2.21								
Sabellaridae	6.78	8.31	0.38	1.38	4.52	1.95	0.18	0.39				
Gastropods	6.78	2.31	4.39	1.07	3.23	0.62	4.36	0.65	1.89	0.06	9.29	0.62
Harpacticoid copepods	4.24	2.08	0.02	0.21	12.26	5.13	0.12	2.61	16.98	17.30	0.26	10.41
Sphaeromatid isopods	4.24	3.00	2.55	0.55	6.45	1.03	1.29	0.61				
Sabellidae	3.39	9.93	1.76	0.93	0.65	1.03	0.26	0.03				
Chlorophyta	3.39	0.92	3.56	0.36	5.81	2.26	2.73	1.17				
Dipteran insects	2.54	1.15	0.11	0.08								
Cumaceans	0.85	0.23	1.16	0.03								
Nereidae	0.85	0.23	4.91	0.10					1.89	0.06	2.92	0.20
Lumbrineridae	0.85	0.23	3.82	0.08								
Crangonid shrimp	0.85	0.23	1.16	0.03	0.65	0.10	4.43	0.12				
Echinoids	0.85	0.23	1.09	0.03								
Ulotrichales					5.81	0.92	8.51	2.22	3.77	0.13	2.65	0.37
Ostracods					3.87	1.73	0.07	0.20				
Bangiales					3.87	0.62	5.11	0.90				
Barnacle cirri					3.87	1.64	0.66	0.36	7.55	66.36	1.49	17.94
Terebellidae					3.87	1.03	9.21	1.60	1.89	0.06	6.90	0.46
Scytosiphonaceae					1.29	0.21	2.36	0.13				
Crustacean larvae					1.29	45.79	1.46	2.47				
Aulacopoda					0.65	1.64	0.22	0.05				
Desmarestiaceae					0.65	0.21	2.73	0.08				
Caridean shrimp					0.65	0.10	1.64	0.05				
Asellotan isopods									7.55	0.45	0.93	0.36
Valviferan isopods									5.66	0.26	0.16	0.08
Bivalves									3.77	0.13	1.73	0.26
Gammaridae									3.77	0.19	1.19	0.18
Hippolytid shrimp									1.89	0.06	7.03	0.47
August tidepool	1976				1977 (n=29)				1978 (n=29)			
Nemerteans					44.83	14.58	33.15	50.62	6.90	0.43	7.34	1.16
Gammarid amphipods					34.48	15.63	2.65	16.76	41.38	3.46	9.40	11.22
Bangiales					20.69	6.25	21.85	13.75				
Polychaete annelids					17.24	5.21	8.68	5.67	37.93	31.10	37.37	54.77
Harpacticoid copepods					13.79	10.42	0.06	3.41	20.69	55.94	0.30	26.57
Ulotrichales					10.34	3.13	8.68	2.89	6.90	0.43	5.01	0.79
Barnacle cirri					10.34	7.29	1.12	2.06	6.90	1.51	0.05	0.23
Sphaeromatid isopods					6.90	2.08	3.74	0.95				
Sabellidae					3.45	10.42	1.12	0.86				
Asellotan isopods					6.90	4.17	0.84	0.82	10.34	1.30	0.75	0.45
Ostracods					10.34	3.13	0.20	0.81				
Gastropods					3.45	2.08	4.67	0.55				
Chlorophyta					6.90	2.08	0.76	0.46				
Terebellidae					3.45	1.04	4.58	0.46				
Rhodophyta					6.90	2.08	0.10	0.36				
Phaeophyta					3.45	1.04	2.99	0.33				
Scytosiphonaceae					3.45	1.04	2.99	0.33				
Bivalves					3.45	3.13	0.19	0.27	6.90	0.43	3.26	0.54
Ampharetidae					3.45	2.08	1.03	0.25				
Bangiaceae					3.45	1.04	0.56	0.13				
Hirudinea					3.45	1.04	0.19	0.10				
Insects					3.45	1.04	0.09	0.09				
Valviferan isopods									10.34	0.86	0.30	0.25
Unidentified debris, sand & algae									10.34	1.51	18.05	4.27
Nematodes									6.90	0.43	0.05	0.07
Gammaridae									6.90	0.65	2.26	0.42
Hippolytid shrimp									3.45	0.22	13.28	0.98

Juvenile English sole were classified as facultative benthivores. This species is a good illustration of prey variability because of its broad distribution over a number of shoreline habitats along the strait. Samples are available from August collections at five of the seven beach-seine sites (excluding Beckett Point) over the three years (Table 36). In general, variability between habitats is greater than between years (Tables 24, 25), although both show considerable differences in prey composition. Tanaids and polychaete annelids were most important in the mud/eelgrass habitat at Jamestown-Port Williams, although gammarid amphipods predominated in 1977. Polychaete annelids and gammarid amphipods were the main prey in the sand/cobble habitat at Twin Rivers and Morse Creek except for the occurrence of holothuroideans at Twin Rivers, and harpacticoid copepods at Morse Creek in 1977. Except for the contribution by cumaceans, prey compositions from Dungeness Spit were the least similar among the three years: gammarid amphipods, mysids, and cumaceans predominated in 1976; cumaceans, gammarid amphipods, and harpacticoid copepods in 1977; and holothuroideans and cumaceans in 1978. The principal difference between 1976 and 1977 prey compositions at Kydaka Beach was the appearance of polychaete annelids in the 1977 sample. The relative contributions of the seven principal prey taxa varied considerably among the 14 separate samples.

Starry flounder, the only large adult flatfish captured in the nearshore region along the Strait of Juan de Fuca, were not caught in high enough numbers to warrant comparison of diet spectra. Two beach-seine samples, August 1977 and 1978, at Kydaka Beach indicated low dietary overlap (Tables 24, 37).

Sand sole were the only flatfish classified as obligate epibenthic planktivores. Except for the series from Twin Rivers, the diet spectra from four sites differed between years (Tables 24, 38). While mysids were often predominant in the prey spectrum, they occurred so sporadically that other prey organisms--fishes, gammarid amphipods, cumaceans, hippolytid shrimp--assumed predominance. Variability was equally extensive for most between-habitat comparisons (Table 25).

In conclusion, examination of the variability in prey compositions among years and habitats for 14 representative nearshore fish species indicated that although a few prey taxa may be important to the diet of a species, the proportional contributions among the prey taxa vary considerably. In general, diet overlap was more consistent between years than between habitats, although the overlap values were equally variable. Trends in increasing contributions of several prey taxa over the three years of the study were noted but could not be verified without corresponding indications of trends in prey abundance at those sites over the three years.

4.9.4 Overlap Between Diet Spectra of Nearshore Fish and Documented Invertebrate Assemblages

The basic problem associated with determining the relative importance of a particular prey taxon to a predator (i.e., the selectivity of the predator) is the measurement of actual prey availability. The lack of concurrent sampling of prey abundance and predator stomachs in the MESA studies along the Strait of Juan de Fuca limits our ability to either

Table 36. Prey composition of juvenile English sole during three years of MESA collections, August 1976, 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, %IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
Jamestown/Port Williams	1976 (n=10)				1977 (n=9)				1978 (n=21)			
Tanaids	80.00	66.97	38.83	56.33	55.56	57.69	20.00	60.11	90.48	69.17	40.25	66.00
Polychaete annelids	70.00	16.20	32.83	35.76	11.11	2.31	8.00	1.05	52.38	13.28	42.30	19.63
Bivalves	40.00	6.70	1.62	2.05					9.52	0.23	0.06	0.02
Cumaceans	30.00	16.09	4.00	4.40	55.56	5.38	2.26	3.90	38.10	5.63	2.06	1.92
Gammarid amphipods	20.00	2.68	11.36	2.28	66.67	33.85	52.96	33.23	71.43	8.55	14.80	11.29
Harpacticoid copepods	10.00	0.67	0.12	0.06					14.29	2.19	0.06	0.22
Glycerid polychaetes	10.00	2.68	11.26	1.13								
Phoronids					11.11	0.77	16.00	1.71				
Ostracods									14.29	0.58	0.40	0.09
Twin Rivers	1976 (n=5)				1977 (n=15)				1978 (n=20)			
Polychaete annelids	60.00	7.56	38.99	27.35	46.67	48.69	9.56	25.79	60.00	18.05	9.63	7.13
Gammarid amphipods	60.00	70.35	38.28	65.86	13.33	16.66	6.82	6.79				
Harpacticoid copepods	20.00	2.76	0.01	0.56								
Mysids	20.00	8.29	6.67	2.93								
Cumaceans	20.00	2.14	1.43	0.77	6.67	0.52	0.01	0.03				
Tanaids	20.00	4.52	0.22	0.93								
Flabelliferan isopods	20.00	1.01	2.08	0.60	6.67	0.52	0.14	0.06				
Valviferan isopods	20.00	0.25	0.86	0.22								
Bivalves	20.00	0.25	0.63	0.18								
Euphausiids	20.00	2.26	0.14	0.47								
Fish	20.00	0.25	10.68	2.14								
Holothuroidea					60.00	25.08	81.16	67.29	85.00	79.62	88.55	92.63
Chlorophyta					6.67	0.52	0.29	0.05				
Potamogetonaceae									10.00	1.00	1.33	0.17
Crane Creek	1976 (n=4)				1977 (n=12)				1978 (n=21)			
Gammarid amphipods	100.00	84.71	88.96	91.48	58.33	12.95	29.35	20.61	71.43	25.08	48.26	46.83
Polychaete annelids	75.00	5.88	7.10	5.16	66.67	7.38	60.52	41.86	71.43	11.63	43.93	35.35
Cumaceans	50.00	4.71	1.89	1.76	66.67	3.08	4.97	6.19	42.86	2.93	1.97	1.88
Idoteid isopods	25.00	1.18	1.62	0.36								
Harpacticoid copepods					41.67	76.26	6.46	31.10				
Holothuroideans					8.33	0.06	1.16	0.09				
Oligochaetes					8.33	0.06	0.71	0.06				
Mysids					8.33	0.12	0.10	0.02				
Caridean shrimp					8.33	0.06	0.10	0.01	9.52	0.20	0.31	0.08
Brachyuran crabs					8.33	0.06	0.10	0.01				
Calanoid copepods									28.57	57.63	1.96	15.22
Ampeliscidae									14.29	0.30	2.30	0.32
Tanaidae									9.52	1.72	1.08	0.21
Bivalves	50.00	3.53	0.63	1.10	8.33	0.06	0.52	0.06	19.05	0.51	0.12	0.11
Dungeness Spit	1976 (n=15)				1977 (n=12)				1978 (n=9)			
Gammarid amphipods	86.70	49.36	21.90	66.69	58.33	15.75	17.69	21.72	44.44	9.90	3.98	6.22
Mysids	60.00	25.11	56.79	17.70					11.11	0.99	0.02	0.11
Cumaceans	60.00	13.42	11.68	11.23	25.00	50.00	66.01	56.56	44.44	72.28	3.69	36.06
Polychaete annelids	20.00	7.93	1.38	1.52	16.67	3.94	6.21	3.11	11.11	0.99	0.02	0.11
Holothuroidea	6.67	0.44	6.59	0.27	8.33	0.30	5.00	0.89	55.56	13.86	90.47	58.46
Unidentified detritus, sand, and algae	6.67	0.44	8.96	0.31								
Ostracods	6.67	0.44	0.11	0.03					11.11	0.99	0.02	0.22
Harpacticoid copepods	6.67	0.44	0.01	0.02	25.00	29.92	1.18	17.21				
Tunicates	6.67	0.44	0.01	0.02								
Kydaka Beach	1976 (n=10)				1977 (n=10)				1978			
Gammarid amphipods	90.00	28.56	56.96	69.08	60.00	15.09	6.52	12.03				
Cumaceans	90.00	49.02	29.24	64.93	70.00	60.11	15.23	61.13				
Harpacticoid copepods	30.00	17.63	0.71	3.67	10.00	0.96	0.02	0.09				
Polychaete annelids	30.00	2.83	2.76	1.07	80.00	10.38	43.66	38.97				
Ostracods	40.00	1.09	1.85	0.75	40.00	3.77	0.63	1.57				
Holothuroidea	10.00	0.22	7.08	0.47	10.00	1.89	2.66	0.60				
Bivalves	20.00	0.44	0.91	0.17								
Nemerteans	10.00	0.22	0.46	0.04								
Valviferan isopods	10.00	0.22	0.02	0.02								
Decapoda, unid.					10.00	3.77	27.62	2.89				
Mysids					10.00	15.09	4.26	1.83				
Flabelliferan isopods					10.00	0.96	0.20	0.11				

Table 37. Prey composition of starry flounder during two years of MESA collections, August 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimentric composition, %IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
	1977 (n=6)				1978 (n=7)			
Ammodytidae	66.67	89.47	93.88	97.78				
Cancrid crabs	16.67	5.26	5.36	1.42	71.43	35.00	83.77	75.21
Unidentified detritus, sand and algae	16.67	5.26	0.76	0.80	42.86	15.00	2.23	6.55
Gammarid amphipods					42.86	17.50	1.14	7.08
Holothuroidea					28.57	15.00	10.29	6.41
Cumaceans					28.57	10.00	0.68	2.70
Flabelliferan isopods					28.57	5.00	1.86	1.74
Polychaete annelids					14.29	2.50	0.02	0.32

Table 38. Prey composition of sand sole during three years of MESA collections, August 1976, 1977, 1978. F.O. = frequency occurrence, N.C. = numerical composition, G.C. = gravimetric composition, %IRI = percent total Index of Relative Importance.

Prey	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI	% F.O.	% N.C.	% G.C.	% IRI
Dungeness Spit	1976 (n=12)				1977 (n=14)				1978 (n=22)			
Mysids	66.67	75.68	33.73	72.99	14.29	10.00	0.74	5.36	86.36	81.66	76.02	90.19
Gammarid amphipods	50.00	15.32	4.20	9.77	28.57	40.00	2.91	42.87	68.18	10.45	2.30	5.76
Crangonid shrimp	33.33	4.50	40.73	15.09	7.14	10.00	11.12	5.27				
Natantian shrimp	8.33	1.80	5.78	0.63								
Idoteid isopods	8.33	0.90	0.43	0.11								
Holothuroideans	8.33	0.90	0.18	0.09								
Ammodytidae	8.33	0.90	14.94	1.32								
Cumaceans					21.43	30.00	0.48	22.84	27.27	5.10	0.98	1.10
Clupeidae					7.14	5.00	51.90	14.21				
Fish larv., juv.					7.14	5.00	32.84	9.45	22.73	0.64	18.07	2.82
Unidentified detritus									4.55	2.04	2.44	0.13
Morse Creek	1976				1977 (n=12)				1978 (n=21)			
Gammarid amphipods					50.00	40.54	2.09	44.44	33.33	26.42	6.24	31.31
Mysids					33.33	32.43	4.18	25.44	9.52	0.94	0.24	0.32
Clupeidae					8.33	2.70	91.77	16.41				
Hippolytid shrimp					25.00	24.32	1.96	13.70				
Fish larvae									19.05	2.36	70.04	39.66
Larvaceans									14.29	50.47	0.30	20.86
Pleuronectidae									4.76	0.94	14.16	2.07
Unidentified detritus									9.52	6.13	1.33	2.04
Polychaete annelids									9.52	0.94	1.58	0.69
Atylidae									4.76	3.77	1.09	0.67
Brachyrhynchan crab larvae									9.52	1.89	0.26	0.59
Ulotrichales									4.76	0.47	3.34	0.52
Caridean shrimp									4.76	1.89	0.47	0.32
Eusiridae									4.76	1.42	0.04	0.20
Twin Rivers	1976 (n=5)				1977 (n=20)				1978 (n=16)			
Mysids	80.00	98.35	69.68	85.57	80.00	78.71	21.04	78.74	68.75	92.16	6.89	78.26
Fishes	80.00	0.51	26.40	13.71	10.00	1.12	45.70	4.62	18.75	1.96	82.67	20.39
Caridean shrimp	20.00	0.21	3.09	0.42	10.00	0.56	8.97	0.94				
Unidentified detritus	40.00	0.51	0.15	0.17								
Crangonid shrimp	20.00	0.10	0.41	0.07	5.00	0.28	1.58	0.09	6.25	0.65	0.18	0.06
Gammarid amphipods	20.00	0.31	0.27	0.07	70.00	17.65	3.45	14.57	25.00	3.27	0.18	9.90
Polychaete annelids					5.00	0.28	15.58	0.78				
Ulotrichales					5.00	0.28	3.39	0.18				
Atylidae									12.50	1.96	0.09	0.29
Kydaka Beach	1976 (n=7)				1977 (n=10)				1978 (n=10)			
Fishes	57.14	7.50	67.59	56.75	60.00	50.00	48.32	85.20				
Mysids	28.57	62.50	11.37	27.92					20.00	5.93	32.56	15.30
Gammarid amphipods	28.57	27.50	2.59	11.37	10.00	8.33	0.15	1.23	40.00	17.80	25.07	34.07
Crangonid shrimp	14.29	1.25	13.08	2.71								
Caridean shrimp	14.29	1.25	5.37	1.25	10.00	8.33	0.40	1.26				
Ammodytidae					10.00	25.00	50.77	10.96				
Unidentified detritus					10.00	8.33	0.37	1.26	10.00	1.69	3.37	1.01
Ulotrichales									10.00	12.71	23.95	7.28
Bivalves									10.00	0.85	7.86	1.73
Calliopiidae									10.00	1.69	0.37	0.41
Eusiridae									10.00	0.85	1.12	0.39
Gammaridae									10.00	0.85	0.75	0.32
Flabelliferan isopods									10.00	0.85	0.75	0.32
Isaeidae									10.00	0.85	0.04	0.18
Cumaceans									10.00	0.85	0.04	0.17
Larvaceans									20.00	55.08	4.21	23.53

appraise the feeding selectivity of the fishes or to establish the importance of different nearshore habitats to the fishes. This latter problem, the need to evaluate shoreline habitats in the context of the nearshore food web, is further hindered by the lack of appropriate sampling methodology for effectively documenting prey organisms.

In the case of neritic plankton communities, the MESA-sponsored investigations by NOAA's Pacific Marine Environmental Laboratory (PMEL) of the phytoplankton, zooplankton, and ichthyoplankton community in the strait (Chester et al. 1977, Chester et al. 1980) provide seasonal documentation of zooplankton composition and estimates of abundance for nine sites. Unfortunately, these sites are in the deepwater regions of the strait and quite distant from the nearshore environs where the neritic (townet) fish collections were made. This does not necessarily preclude comparisons with the prey composition of obligate planktivores such as juvenile Pacific herring and Pacific sand lance which tend to feed exclusively on pelagic calanoid copepods. If assumptions about advection of these zooplankters from deep water into shallow water can be made, then the data from the PMEL study may be descriptive of the prey community available to these neritic fishes.

The epibenthic plankton assemblages exploited by the facultative planktivores have not been documented on a seasonal basis by quantitative sampling and were only crudely sampled (large forms only) during the townet collections of neritic fish. Since epibenthic crustaceans such as mysids and shrimp are important, some quantitative documentation of their composition and distribution in neritic waters will be necessary before evaluation of the available prey resources in different nearshore habitats can be made.

Other MESA studies include quantitative surveys of the intertidal and shallow subtidal benthos along the Strait of Juan de Fuca (Nyblade 1979, Webber 1979) which have been conducted concurrently with the nearshore fish collections since 1976. These data provide the best index of infaunal organisms available to nearshore fish in the specific habitats surveyed. Polychaete annelids, bivalve molluscs, gastropod molluscs, and a number of other organisms which typically remain within or upon the sediment were available for quadrat, core, or Van Veen grab sampling at low tide when the surveys were conducted. Many organisms, however, were not adequately sampled either because they actively move with the tide or because they were too small to be retained by the 1-mm mesh sieve. Some of these--e.g., gammarid amphipods, cumaceans, mysids, harpacticoid copepods--were known to be important components of the diets of many fish (Cross et al. 1978). Subtidal sampling with a Van Veen grab possesses many of the same biases inherent in intertidal surveys because of the avoidance capability of epibenthic zooplankton.

An experiment was conducted under the sponsorship of MESA to attempt quantitative documentation of epibenthic zooplankton in the intertidal and shallow subtidal regions when the tide was in and the organisms were available to predation by nearshore fish (Simenstad et al. 1980). Sampling of the epibenthic zooplankton was coordinated with the sampling of nearshore fish during August 1978 and was designed to provide data directly comparable with the results of the stomach analyses conducted on the predominant nearshore fish collected at that time. Sampling of the epibenthos, described in

Simenstad et al. (1980), utilized a suction pump and sampling cylinder designed to reduce zooplankton avoidance and enable the sampling of microhabitats within the various sampling sites. Sampling was conducted directly upon the shallow subtidal or intertidal area sampled for nearshore fishes by beach seine or in tidepool collections. Discrete samples were taken, however, in distinct microhabitats found within these areas. Depths of the sampled microhabitats varied between 0.1 and 3.0 m.

The results of this survey, provided in detail in Simenstad et al. (1980), are summarized in Table 39 as the percentage composition of invertebrate taxa by abundance and biomass, and in Fig. 11, indicating the total abundance and total biomass (wet weight) of the epibenthic fauna at the six sampling sites and the various microhabitats sampled therein. Comparable prey spectra from concurrently sampled nearshore fish were described previously for predominant species in Appendix 6.1. Overlap of the numerical and gravimetric composition of the epibenthic fauna and the diet of the prevalent nearshore fish sampled at the various sampling sites has been estimated using Sanders' Index of Affinity (Table 40).

The most impressive result of the epibenthic survey is the abundance and numerical dominance by harpacticoid copepods at virtually every site and microhabitat sampled. In one sample--Port Williams, eelgrass--harpacticoids even dominated the fauna on the basis of total biomass. Although seemingly too small (0.250-1.50 mm) to constitute preferred prey for most nearshore fishes, harpacticoids were important in the diets of sharpnose sculpin, tidepool sculpin, high cockscomb, and juvenile English sole. Harpacticoid copepods are probably important prey of primary carnivores, including polychaete annelids, shrimp, and crabs, which are preyed on by nearshore fishes (Simenstad et al. 1979). Differences in total epifauna density and biomass among the sites and microhabitats (Fig. 11) are primarily a function of the abundance and biomass of the harpacticoid copepods.

Overlap values in the stomach contents of the nearshore fish and the epibenthic plankton samples were generally low for most species, principally because of the discrepancies between the presence of harpacticoid copepods in the microhabitat and their presence in the stomach contents of the fishes. Several species, including tube-snout, tidepool sculpin, tubenose poacher, juvenile English sole, and speckled sanddab, preyed heavily on the harpacticoids and therefore exhibited higher overlap in their diet spectra and the environment. In general, overlap values were appreciably higher in comparisons of biomass than in comparisons of numerical composition of the prey organisms (Table 40). This may be a result of two related phenomena: (1) The high numerical contribution of the harpacticoid copepods in the diet is not reflected in the total biomass; thus, other prey organisms contribute higher percentages to the overlap value based on biomass. (2) Prey selection by the fish is most likely to be based on size of prey rather than density (Griffiths 1975, Eggers 1977); therefore, overlap in larger prey organisms based on biomass tends to be higher than overlap based on density. This suggests that within certain size ranges, the standing crop (weight/area or volume) of particular prey organisms may provide a more appropriate measure of the importance of a habitat to nearshore fish than the density.

Table 39. Composition by abundance and biomass of epibenthic zooplankton in various microhabitats at six sites along the Strait of Juan de Fuca, August 1978. Detailed descriptions of microhabitats appear in Simenstad et al. (1980).

	Beckett Point					
	Bare sand		0.3-m Eelgrass		1-m Eelgrass	
	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass
Harpacticoid copepods	79.88	6.31	72.93	20.69	71.50	28.70
Calanoid copepods	4.45	9.16	2.09	1.18	0.45	0.23
Cyclopoid copepods	3.07	6.01	3.52	1.47	1.40	0.44
Bivalves	1.40	6.31	0.41	0.32	0.15	0.22
Gammarid amphipods	0.74	13.51	0.36	2.06	0.26	1.64
Asellotan isopods	0.02	0.15	0.59	0.30	0.41	0.50
Cumaceans	0.03	0.15	—	—	—	—
Hippolytid shrimp	0.03	6.01	0.60	51.55	0.68	50.14
Neogastropoda	0.05	12.01				
Gastropods	0.48	10.66	1.30	12.40	0.36	8.26
Spionid polychaetes	0.68	3.00	0.01	0.01	0.05	0.11
Polychaete annelids	0.49	3.90	6.59	1.09	5.21	7.84
Nematodes	2.83	6.16			0.30	0.22
Ostracods	1.02	6.01	1.44	0.60	0.81	0.34
Harpacticoid eggs	3.75	6.01	4.44	0.59	5.48	0.22
Caridean shrimp			1.31	0.29	0.00	0.01
Crustacean eggs					11.81	3.89
Tanaids	0.75	3.30	2.34	0.62	0.32	0.28
Shannon-Wiener Diversity Index (H')	1.41	4.30	1.88	2.65	1.73	2.29

	Port Williams			
	Coarse sand		1-m Eelgrass	
	Abundance	Biomass	Abundance	Biomass
Harpacticoid copepods	68.23	35.73	84.07	54.31
Cumaceans	20.84	42.00	3.25	2.40
Ostracods	2.88	1.15	3.70	3.93
Hippolytid shrimp	0.03	10.54	0.00	2.27
Bivalves	0.12	1.82	0.16	1.17
Harpacticoid eggs	5.27	0.65	1.88	0.11
Gastropods	0.02	0.03	0.30	10.76
Calanoid copepods	0.43	0.96	1.45	0.43
Tanaids	0.37	0.49	0.59	0.89
Shannon-Wiener Diversity Index (H')	1.49	2.31	1.27	2.94

	Dungeness Spit	
	Coarse sand, gravel	
	Abundance	Biomass
Harpacticoid copepods	70.50	7.26
Cumaceans	10.17	23.89
Nematodes	2.35	2.46
Ostracods	4.53	2.34
Harpacticoid copepod eggs	1.51	2.34
Hydroids	2.27	2.34
Gastropods	0.53	22.37
Polychaete annelids	0.87	14.05
Gammarid amphipods	3.49	12.42
Caprellid amphipods	0.84	2.57
Calanoid copepods	0.76	2.34
Tanaids	1.06	2.46
Shannon-Wiener Diversity Index (H')	2.29	4.14

Table 39. (Contd.)

	Morse Creek					
	Bare sand		Cobble		Sand and cobble	
	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass
Harpacticoid copepods	53.35	16.19	92.28	6.28	52.62	14.19
Calanoid copepods	39.90	27.15	1.53	3.36	30.21	34.80
Mysids	0.24	15.92	0.04	0.15	0.24	10.14
Cyclopoid copepods	1.84	10.44	—	—	7.43	13.85
Cumaceans	0.05	0.26	0.25	3.21	—	—
Nematodes	0.92	5.22	—	—	—	—
Bivalves	0.92	5.22	—	—	—	—
Chaetognaths	0.92	5.22	—	—	—	—
Gammarid amphipods	0.38	3.91	1.83	44.41	0.12	0.34
Pinnotherid crabs	0.05	2.61	—	—	0.12	0.34
Gastropods	0.18	0.52	0.41	21.00	0.12	0.34
Caprellid amphipods	—	—	0.04	4.59	—	—
Polychaete annelids	—	—	0.73	3.06	—	—
Barnacle larvae	—	—	0.73	3.06	—	—
Crustacean eggs	—	—	0.73	3.06	—	—
Asellotan isopods	—	—	0.08	1.68	—	—
Idoteid isopods	—	—	0.04	1.53	—	—
Ostracods	—	—	—	—	2.56	7.09
Harpacticoid copepods	—	—	—	—	2.68	7.09
Spionid polychaetes	—	—	0.84	3.21	2.44	6.76
Tanaids	0.96	5.48	—	—	—	—
Shannon-Wiener Diversity Index (H')	2.05	4.01	0.68	4.03	2.29	3.56

	Kydaka Beach	
	Bare sand	
	Abundance	Biomass
Harpacticoid copepods	37.92	11.81
Copepod nauplii	16.73	7.87
Spionid polychaetes	16.74	11.81
Calanoid copepods	7.15	12.60
Barnacle larvae	3.35	11.81
Crustacean eggs	5.58	7.87
Nematodes	4.46	7.88
Harpacticoid eggs	2.23	3.94
Cyclopoid copepods	3.35	7.88
Epicaridean isopods	1.12	3.94
Gammarid amphipods	0.40	10.05
Shannon-Wiener Diversity Index (H')	3.26	4.40

	Twin Rivers	
	Bare sand	
	Abundance	Biomass
Harpacticoid copepods	42.63	8.44
Copepod nauplii	15.00	5.55
Calanoid copepods	5.12	5.69
Oligochaetes	2.75	2.91
Pycnogonids	2.50	2.77
Ostracods	2.50	2.77
Cyclopoid copepods	2.50	2.77
Barnacle nauplii	2.50	2.77
Mysids	2.48	43.12
Cumaceans	2.50	2.77
Gammarid amphipods	6.11	10.12
Unidentified eggs	2.74	3.05
Cnidarians	0.37	6.93
Shannon-Wiener Diversity Index (H')	3.05	4.14

	Slip Point tidepools											
No.:	1		2		3		4		5		6	
Microhabitat—algae and sessile inverts.:	*Costaria*, *Ulva* & *Hedophyllum*		*Codium*, *Alaria*, & *Hedophyllum*		Corallines, *Phyllospadix*		Unident. brown, *Mytilus*		Unident. brown, *Ulva*, *Mytilus*		No algae, *Mytilus*	
Volume:	0.080 m^3		0.076 m^3		0.112 m^3		0.046 m^3		0.176 m^3		0.067 m^3	
Tide height:	+0.01 m		0.0 m		+0.34 m		+1.07 m		+1.01 m		+1.19 m	
	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass
Harpacticoid copepods	80.58	0.53	71.57	2.62	70.71	0.58	79.67	4.86	58.81	0.98	66.12	1.91
Gammarid amphipods	9.01	21.58	12.58	24.41	15.63	28.75	6.48	34.95	6.42	10.48	5.74	31.03
Ostracods	1.36	1.30	0.03	0.06	2.48	0.61	2.40	4.63	1.11	0.98	0.05	0.09
Harpacticoid eggs	2.43	0.51	5.45	1.25	—	—	—	—	3.67	0.89	2.97	1.81
Nematodes	1.39	0.53	2.91	1.31	0.68	0.58	7.32	4.86	9.32	0.94	4.70	1.91
Archaeogastropods	0.07	41.79	0.16	4.37	1.48	5.56	—	—	0.23	2.27	1.19	7.25
Brittlestars	—	—	—	—	0.36	25.26	—	—	0.62	32.14	0.05	5.44
Oligochaetes	0.80	6.58	0.65	4.37	0.02	0.03	0.24	0.23	0.57	1.32	0.40	0.91
Sphaeromatid isopods	0.09	3.23	0.22	13.73	0.20	3.92	0.12	0.23	0.37	9.82	0.05	0.09
Mesogastropods	—	—	—	—	0.06	6.38	—	—	—	—	0.15	20.87
Pagurid crabs	—	—	—	—	0.03	1.67	—	—	—	—	0.05	4.34
Unidentified eggs	0.08	0.51	0.54	1.25	—	—	—	—	0.05	0.04	0.05	0.09
Idoteid isopods	—	—	—	—	0.08	2.23	—	—	0.02	0.45	0.05	0.91
Polychaete annelids	1.74	17.51	3.67	44.63	2.56	12.92	0.24	9.49	11.57	21.36	5.50	12.42
Anthozoans	0.03	1.01	—	—	—	—	—	—	—	—	—	—
Halacarid mites	0.82	0.53	0.54	1.25	2.12	0.58	—	—	1.38	0.89	—	—
Asellotan isopods	0.31	0.57	0.71	1.37	1.61	3.06	0.12	0.23	2.55	1.86	3.49	4.62
Neogastropods	0.03	1.05	0.54	1.25	0.07	1.94	0.12	2.31	0.13	3.13	0.84	1.00
Cumaceans	0.08	0.25	0.03	0.06	0.81	1.11	0.24	0.23	0.18	0.89	2.08	1.91
Cirolanid isopods	—	—	—	—	0.02	1.67	—	—	—	—	—	—
Hippolytid shrimp	—	—	0.03	0.62	—	—	0.12	32.41	0.02	5.36	—	—
Gastropod eggs	0.01	0.03	—	—	0.08	0.28	2.40	4.63	0.05	0.04	0.05	0.09
Bivalves	0.33	0.56	0.11	0.12	0.07	0.06	—	—	0.25	3.12	2.87	1.81
Crustacean eggs	0.54	0.31	—	—	0.30	0.56	—	—	1.54	0.94	0.10	0.09
Shannon-Wiener Diversity Index (H')	1.41	3.38	1.87	3.80	2.88	4.05	1.29	2.97	2.65	4.07	2.36	4.26

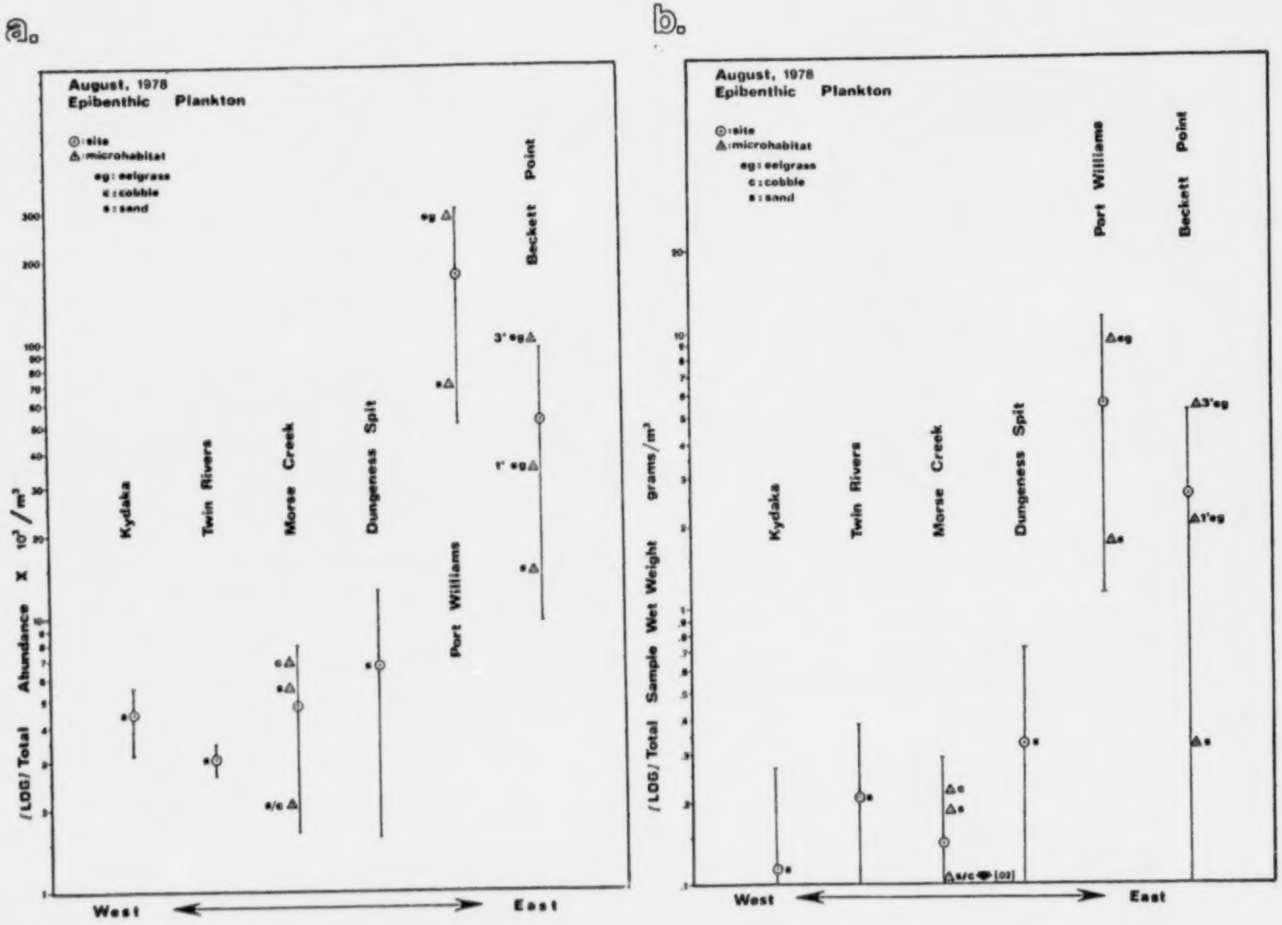

Fig. 11. Total abundance and total biomass of the epibenthic fauna at six sites in the Strait of Juan de Fuca sampled in August 1978.

Table 40. Percent overlap (Sanders' Index of Affinity) between epibenthic zooplankton and diet of nearshore fish at seven sites (17 distinct microhabitats) along the Strait of Juan de Fuca, August 1978.

	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass
Beckett Point	Bare sand		0.3m Eelgrass		1m Eelgrass	
Pacific tomcod juv.	0.52	6.02	7.19	51.56	5.89	50.15
Tube-snout	52.69	6.51	58.72	52.05	51.22	50.64
Widow rockfish juv.	1.80	9.36	3.73	51.61	1.81	50.20
Padded sculpin	2.17	15.42	2.68	39.73	1.10	38.93
Pacific staghorn sculpin	3.41	0.50	8.70	0.74	1.46	0.40
Tidepool sculpin	9.26	24.63	10.67	4.24	6.54	10.32
Tubenose poacher	0.03	6.01	1.91	9.97	0.68	50.15
Pile perch	1.05	23.62	1.87	13.25	0.82	8.77
Crescent gunnel	11.25	76.57	11.40	54.02	5.30	58.92
Speckled sanddab	3.41	7.62	8.59	6.41	4.98	6.03
Jamestown-Port Williams	Coarse sand		1m Eelgrass			
Pacific staghorn sculpin	0.97	11.53	1.16	3.66		
Tidepool sculpin	69.06	38.32	85.52	29.52		
English sole juv.	8.11	2.63	6.19	3.03		
Dungeness Spit	Coarse sand, gravel					
Pacific tomcod juv.	4.05	2.46				
Pacific staghorn sculpin	0.24	0.79				
Speckled sanddab	14.32	12.10				
English sole juv.	15.52	17.95				
Sand sole juv.	8.59	3.28				
Morse Creek	Bare sand		Cobble		Sand & cobble	
Pacific tomcod juv.	46.99	22.45	10.17	49.00	36.99	2.64
Tube-snout	79.38	37.24	74.86	10.69	78.65	35.24
Widow rockfish juv.	0.67	7.50	2.89	43.78	0.36	4.77
Silverspotted sculpin	0.62	7.57	1.87	44.56	0.36	4.00
Pacific staghorn sculpin	1.16	0.04	0.81	0.55	0.24	0.13
Tubenose poacher	53.73	10.20	62.15	50.69	52.74	6.63
Speckled sanddab	0.38	3.91	2.56	44.69	0.12	0.34
English sole juv.	40.84	6.23	4.34	51.38	30.33	2.28
Sand sole juv.	0.62	4.14	2.60	11.70	0.36	0.57
Twin Rivers	Bare sand					
Padded sculpin	6.11	1.18				
Rosylip sculpin	8.59	15.46				
Silverspotted sculpin	8.59	53.24				
Pacific staghorn sculpin	6.11	0.03				
Tidepool sculpin	42.80	18.56				
Tubenose poacher	8.59	46.35				
Redtail surfperch	7.02	11.49				
Striped seaperch	8.38	10.16				
Penpoint gunnel	8.59	10.20				
Speckled sanddab	8.59	34.73				
English sole	0.00	0.00				
Sand sole juv.	7.71	7.46				

Table 40. (Contd.)

Morse Creek	Bare sand		Cobble		Sand & cobble	
Pacific tomcod juv.	46.99	22.45	10.17	49.00	36.99	2.64
Tube-snout	79.38	37.24	74.86	10.69	78.65	35.24
Widow rockfish juv.	0.67	7.50	2.89	43.78	0.36	4.77
Silverspotted sculpin	0.62	7.57	1.87	44.56	0.36	4.00
Pacific staghorn sculpin	1.16	0.04	0.81	0.55	0.24	0.13
Tubenose poacher	53.73	10.20	62.15	50.69	52.74	6.63
Speckled sanddab	0.38	3.91	2.56	44.69	0.12	0.34
English sole juv.	40.84	6.23	4.34	51.38	30.33	2.28
Sand sole juv.	0.62	4.14	2.60	11.70	0.36	0.57

Twin Rivers	Bare sand	
Padded sculpin	6.11	1.18
Rosylip sculpin	8.59	15.46
Silverspotted sculpin	8.59	53.24
Pacific staghorn sculpin	6.11	0.03
Tidepool sculpin	42.80	18.56
Tubenose poacher	8.59	46.35
Redtail surfperch	7.02	11.49
Striped seaperch	8.38	10.16
Penpoint gunnel	8.59	10.20
Speckled sanddab	8.59	34.73
English sole	0.00	0.00
Sand sole juv.	7.71	7.46

Kydaka Beach	Bare sand	
Lingcod juv.	0.00	0.00
Pacific staghorn sculpin	1.52	3.27
Redtail surfperch	1.72	7.90
Speckled sanddab	1.54	7.44
Starry flounder	4.02	3.02
Sand sole juv.	1.25	13.99

	Tidepool Number											
	1		2		3		4		5		6	
Slip Point	Abund	Biom	Abund	Biom	Abund	Biom	Abund	Biom	Abund	Biom	Abund	Biom
Tidepool sculpin	10.46	32.00	13.32	26.40	28.39	29.26	80.20	13.66	66.54	15.35	39.85	10.51
High cockscomb	--	--	13.29	25.78	35.97	41.75	0.24	9.49	14.34	30.42	16.73	22.22

The epibenthic pump sampling appeared to be appropriate for the sampling of several important prey organisms in addition to harpacticoid copepods. The best example is that of hippolytid shrimp which, due to their size, contributed significantly to the prey spectra of juvenile Pacific tomcod, juvenile widow rockfish, tubenose poachers, and several other species in certain habitats, especially those at Beckett Point. Other prey taxa which indicated relatively high correlation with epibenthic fauna at different sites included tanaids, cumaceans, calanoid copepods (especially at Morse Creek), and polychaete annelids.

Several taxa of epibenthic crustaceans, which are important in the prey spectra of nearshore fishes, may not have been effectively sampled during the survey. The two most notable taxa are sphaeromatid isopods and mysids. Although sampled by the suction pump, they did not represent the proportion of the total epibenthos which was reflected by their occurrence in the stomach contents of the predators. This was especially true at the exposed sites of Dungeness Spit and Kydaka Beach, where mysids formed an important component of the prey spectra of such species as juvenile Pacific tomcod, juvenile English sole, and sand sole, and yet were not sampled at all. This suggests (1) extensive selection of these taxa by nearshore fishes; (2) ineffective sampling using the suction pump; or (3) differential occurrence of the organisms in the water column between the time of the beach seining and the time of the epibenthic pump sampling. In the case of the mysids, it is suspected that their patchy distribution and probable diel aggregation in the water column also contribute to the lack of sample overlap. Systematic diel sampling, perhaps coordinated with nearshore epibenthic sled sampling or plankton net sampling by SCUBA diver, would have to be conducted before the question of mysid availability will be resolved.

Results from the epibenthic pumping of tidepools at Slip Point indicated that sphaeromatid isopods were available to the pump, at least in the situation of a contained volume of water which was completely filtered. Sphaeromatid isopods are mainly associated with rocky nearshore habitats and are preyed on by the fishes found in that habitat--prickleback, gunnel, and some sculpins.

The lack of overlap in epibenthic pump samples and stomach samples in some instances was associated with the inability of the suction pump to capture large epifauna such as crabs, true infauna such as bivalves, some polychaete annelids, and fish. Diets of predators utilizing these organisms, such as staghorn sculpin, cannot be adequately assessed using only this methodology even though they can be considered to be principally epibenthic carnivores. Similarly, sessile organisms such as barnacles often contribute measurably to the diets of fish inhabiting rocky nearshore areas; overlap in the epibenthic assemblage will also be low in these cases.

Gammarid amphipods, although not always a prevalent group numerically, usually contributed significantly to the total biomass of the stomach contents of many nearshore fish species and were especially prominent in the tidepools sampled in the rocky intertidal habitat at Slip Point.

According to occurrence in the diets of predominant nearshore fish collected at all nearshore sites along the strait (Table 41, Appendix 6.10),

Table 41. Gammarid amphipod species consumed by 12 common species of nearshore fish collected along Strait of Juan de Fuca, August 1978. + = occurrence, ● = abundant; number is mean wet weight in grams.

Prey	Pacific tomcod	Widow rockfish	Padded sculpin	Smooth-head sculpin	Rosylip sculpin	Tidepool sculpin	Fluffy sculpin	Redtail surf-perch	High cockscomb	Ribbon prickle-back	Black prickle-back	Crescent gunnel
Gammaridea												
Amphithoidae												
Amphithoe simulans						+ 0.0210						
Aoridae												
Aoroides columbiae						+ 0.0068			+ 0.0010			+ 0.0010
Atylidae												
Atylus tridens	+ 0.004	+ 0.0307		+ 0.0076				+ 0.0010		+ 0.0310	+ 0.0137	
Calliopiidae												
Calliopiella pratti						+ 0.0080						
Eusiridae						+ 0.0070						
Accedomoera vagor	● 0.0006	● 0.0013										+ 0.0003
Pontogeneia ivanovi					+ 0.0190							
Gammaridae												
Anisogammarus pugettensis	+ 0.0130	+ 0.0180										
Melita californica						+ 0.0020						
M. desdichada		+ 0.0070			● 0.0023	● 0.0024			● 0.0030			
Hyalellidae												
Najna consiliorum		+ 0.0030										
Hyalidae						+ 0.0018	+ 0.0001					
Hyale sp.		+ 0.0075			+ 0.0020							
H. rubra		+ 0.0040				● 0.0006	+ 0.0013					● 0.0014
Parallorchestes ochotensis		+ 0.0030			+ 0.0040	+ 0.0100			+ 0.0030			
Isaeidae												
Photis sp.						+ 0.0017						
P. brevipes			+ 0.0012									
Podoceropsis sp.		+ 0.0001										
Ischyroceridae												
Ischyrocerus sp.					+ 0.0010							
Oedicerotidae												
Monoculodes sp.	+ 0.001											
Synchelidium shoemakeri	+ 0.0001											
Phoxocephalidae												
Mandibulophoxus gilesi	+ 0.0004											
Pleustidae												
Parapleustes pugettensis												+ 0.0004
Talitridae												
Orchestia sp.					+ 0.0020							

the prevalent amphipods included Aoroides columbiae, Atylus tridens, Accedomoera vagor, Melita californica, M. desdichata, Hyale rubra, and Parallorchestes ochotensis. There was considerable overlap in amphipods in stomach contents and those in plankton pump samples, especially with Aoroides columbiae and Melita desdichata (both exclusively collected in tidepools) and Hyale rubra and Ischyrocerus sp. There were more cases where the epibenthic pump sampled species were not utilized by the nearshore fish (Amphilocus littoralis, Gitanopsis vilordes, Amphithoe sp., A. simulans, A. lacertosa, Calliopius sp., Corophium sp., C. baconi, Pontogeneia rostrata, Maera simile, Megaluropus sp., Eohaustorius washingtonianus, Allorchestes angustus, Jassa falcata, Lepidepecreum gurjanovae, Orchomene sp., Paraphoxus sp., and P. spinosus). To a lesser extent, species occurred in stomach contents which had not been sampled during the epibenthic survey (Melita californica, Najna consiliorium, and Orchestia sp.). Although we cannot verify the actual availability of these amphipod species to the fish predators, it would appear that (1) the pump quantified the majority of the amphipods preyed on by the fish and especially the more common prey species, and (2) the fish used only a fraction of the species (and numbers) of amphipods potentially available to them. By examining the characteristic habitat types of the species consumed by the fish, we see that the majority of the consumed species are algae-associated, as compared with those which which are not preyed on, which are typically sediment-associated (Simenstad et al. 1980). There is also good evidence for selectivity by the fish for the larger species and sizes (within species) of amphipods available to them; in almost all cases, the prevalent amphipods among the stomach contents had a higher mean wet weight (Table 41) than those collected by the epibenthic pump (Table 42). If there are no size-related avoidance biases by amphipods during pump sampling, we can theorize that the fish are optimizing their energy intake per prey organism by selectively feeding on the large species and groups available in the environment (Griffiths 1975). The implication of such selective feeding is that only a portion of the available assemblage of prey organisms constitutes optimum food sources for nearshore fish, and that habitats where the abundance of epibenthos has been reduced by seasonal phenomena or unnatural perturbations--or where the prey species or size composition has been altered--may not support an equivalent density or composition of nearshore fishes.

4.10 POTENTIAL EFFECTS OF PETROLEUM HYDROCARBONS ON THE NEARSHORE FISH COMMUNITIES ALONG THE STRAIT OF JUAN DE FUCA

There is little doubt that major releases (greater than 42,000 gallons--1,000 barrels or 150 tons) of petroleum hydrocarbons adversely affect marine environments. Recent evidence has documented the conditions under which petroleum is toxic to aquatic organisms (Baker 1978, Am. Inst. Biol. Sci. 1976, Wolfe 1977, Malins 1977, McIntyre and Whittle 1977, Fish. Res. Board Can. 1978). In most cases, acute toxicity has been stressed; problems of sublethal and chronic toxic effects have only recently been addressed. There is still considerable controversy about the "significance" of petroleum-induced perturbations to biological communities--i.e., the longevity of the impact, the effect of significant reduction of prey populations of important consumer species, the transfer of hydrocarbons or metabolites from prey to predator, and the rates of biological succession in determining the recovery of a damaged ecosystem. Furthermore, the ability to detect actual changes in density, productivity, or community structure which

Table 42. Occurrence and relative size of gammarid amphipods collected by epibenthic plankton pump sampling in the Strait of Juan de Fuca, August 1978. Number below occurrence values is relative size in grams wet weight per individual.

	Beckett Point		Point Williams		Dungeness Spit		Morse Creek		Twin Rivers		Slip Point		Kydaka Beach	
Gammarid amphipod	#/m^3	g/m^3	#/m^3	g/m^3	#/m^3	g/m^3	#/m^3	g/m^3	#/m^3	g/m^3	#/m^3	g/m^3	#/m^3	g/m^3
Gammaridea											105.3 0.0001	0.010		
Ampeliscidae														
Arphilecus littoralis			2.5 0.0001	0.000										
Citomopsis vilordes			26.3 0.0001	0.002										
Amphithoidae														
Amphithoe sp.			7.5 0.0007	0.005							15.0 0.0011	0.020		
A. simulans			3.8 0.0003	0.001										
A. lacertosa	0.8 0.0010	0.010	290.8 0.0002	0.053										
Aoridae														
Aoroides columbiae	66.7 0.0009	0.034									1705.4 0.0003	0.133		
Atylidae														
Atylus sp.							0.8 0.0001	0.000						
Calliopiidae														
Calliopius sp.	0.8 0.0020	0.010							7.7 0.0010	0.000				
Calliopiella pratti	0.8 0.0020	0.010	108.7 0.0004	0.080	5.0 0.0001	0.001	0.8 0.0001	0.000	3.8 0.0001	0.000	3044.9 0.0000	0.053	5.0 0.0005	0.003
Corophiidae														
Corophium sp.			127.5 0.0001	0.037							78.8 0.0001	0.000		
C. baconi			1.3 0.0001	0.000										
Eusiridae			76.3 0.0001	0.005										
Accedomoera vagor			57.6 0.0002	0.014			4.2 0.0012	0.005						
Pontogeneia sp.	0.8 0.0010	0.001	28.9 0.0001	0.003	5.0 0.0001	0.000								
P. rostrata	14.1 0.0011	0.050	908.8 0.0004	0.347			6.6 0.0004	0.004			2.1 0.0001	0.000	5.0 0.0005	0.003
Gammaridae									76.9 0.0001	0.008	2.1 0.0001	0.000		
Maera simile													2.5 0.0020	0.005
Megaluropus longimerus							1.7 0.0010	0.002						
Melita desdichata											344.3 0.0017	0.450		
Haustoriidae														
Eohaustorius washingtonianus					7.5 0.0003	0.003								
Hyalellidae														
Hyalidae			75.0 0.0000	0.002							6.3 0.0000	0.000		
Allorchestes angustus									19.2 0.0002	0.004				
Hyale sp.			1.3 0.0001	0.000					78.9 0.0001	0.008				
H. rubra			1.3 0.0001	0.000			0.8 0.0010	0.001			27.1 0.0008	0.019	2.5 0.0010	0.005
Parallorchestes ochotensis							3.3 0.0018	0.006						
Isaeidae														
Photis sp.	66.7 0.0001	0.005	103.8 0.0001	0.005	50.0 0.0001	0.005					139.6 0.0001	0.010		
P. brevipes			2.5 0.0030	0.008										
Protomedeia sp.			7.5 0.0004	0.001										
Podoceropsis sp.			325.1 0.0001	0.057	2.5 0.0001	0.000								
Ischyroceridae			25.0 0.0001	0.002										
Ischyrocerus sp.	2.5 0.0001	0.000	508.8 0.0001	0.062	7.5 0.0003	0.000	23.9 0.0004	0.007			2.1 0.0001	0.000		
Jassa falcata											3.2 0.0001	0.000		

Table 42. (Contd.)

Lysianassidae					
Lepidepecreum gurjanovae	1.3 0.033 0.0001				
Orchomene sp.	1.3 0.009 0.0001				
Oedicerotidae					
Monoculodes sp.		113.0 0.008 0.0002			
Synchelidium sp.					
S. shoemakeri	1.3 0.000 0.0001		3.3 0.001 0.0003		
Phoxocephalidae					
Paraphoxus sp.					
P. spinosus	22.5 0.006 0.0001			23.7 0.007 0.0001	
Mandibulophoxus gilesi		37.5 0.009 0.0002	0.8 0.001 0.0001		2.5 0.040 0.0001
Pleustidae					
Parapleustes nautilus				2.1 0.000 0.0001	

can be attributed to increased hydrocarbon concentrations in the environment is often lacking.

A discussion of the potential effects of petroleum on the marine food webs and nearshore communities of northern Puget Sound and the Strait of Juan de Fuca is presented in Simenstad et al. (1980). The following is a discussion of the results of the three years of nearshore fish surveys along the strait as they relate to the vulnerability of nearshore fish assemblages to the effects of petroleum. A discussion of the quantitative usefulness of the nearshore fish data to detect measurable changes in fish density and biomass has been presented earlier in this report.

The effect of petroleum on the neritic fish assemblage may vary with the species involved. The juveniles and adults of the species (especially Pacific herring, Pacific sand lance, and longfin smelt) appear to be transient in the nearshore region. Since they have the ability to detect low concentrations of petroleum hydrocarbons in the water, neritic fishes may be capable of seeking uncontaminated areas. Certain species in the neritic fish assemblage, however, are strongly associated with the nearshore region, particularly the juveniles of several species of Pacific salmon, the most economically important food fish in the region. The use of drift, epibenthic, and pelagic prey organisms by those species ensures the transport of hydrocarbons to higher levels in the food web.

Because of its lack of mobility and high sensitivity to hydrocarbons in low concentrations, the ichthyoplankton component of the neritic fish assemblage may be especially vulnerable to oil spills. It has been demonstrated that the success of neritic fish larvae in locating and feeding on patchily distributed food organisms determines their survival past this critical life history stage (Arthur 1976, Hunter and Thomas 1974, Lasker et al. 1970, Laurence 1974, May 1974, O'Connell and Raymond 1970, Rosenthal and Hempel 1973). Disruption of the phytoplankton and microzooplankton preyed on by the larval fish during the first few weeks of their pelagic life, even though only local, may result in significant larval mortalities.

The nearshore demersal fish assemblages may be vulnerable to the toxic effects of petroleum present in intertidal and shallow subtidal regions because of their restriction to these regions. Although demersal fishes may have the same capability as neritic species to detect water contaminated by petroleum hydrocarbons, they may not be able to avoid contaminated waters. Juveniles of many species (e.g., English sole, sand sole, Pacific tomcod, chum salmon) use the nearshore environment as a nursery ground. In a sense they are ecologically constrained to the nearshore environment. If these fishes did behaviorally avoid contaminated areas by moving into deeper water they would probably suffer increased mortalities as a result of increased predation and lack of appropriate food resources.

Among the habitats studied during the three years of nearshore fish surveys, the protected bays, such as Beckett Point and Port Williams, would seem to possess the greatest potential for damage to the biotic community. Not only were species richness, density, and standing crop of the nearshore fishes typically highest in these habitats, but also the reduced exposure to wave action would prolong the period required to weather spilled petroleum beyond a toxic state. Investigators of the 1969 West Falmouth oil (No. 2 fuel) spill found that in fine sediment, saltmarsh habitats, petroleum became incorporated into the sediments where it was preserved in a moderately toxic state until recycled by benthic infaunal organisms or physically removed by wave action and erosion (Blumer and Sass 1972a,b, Krebs and Burns 1977 , Teal et al. 1978). Although the water over oiled sediments may not reach toxic levels through the leaching process, sublethal but deleterious levels may be maintained for many years and the prey organisms used by the fish may continue to act as transporters of petroleum hydrocarbons from the sediments to the fish.

The results of the food habits studies of the predominant nearshore fish species described in this and other reports (Simenstad et al. 1977, Cross et al. 1978, Simenstad et al. 1979) document the importance of detritivorous organisms, especially epibenthic crustaceans, to the nearshore fish in the region. Eelgrass (Zostera marina) may be one of the most important sources of detritus in the nearshore ecosystem (McRoy and Herfferich 1977) and may also act as sediment traps, serving to entrain detrital particles where they can be utilized by the abundant detritivorous crustaceans in this habitat (Kikuchi and Peres 1977). The epibenthic plankton pump sampling in August 1978 (this report; Simenstad et al. 1980) revealed that the density and standing crop of epibenthic organisms were higher in eelgrass beds than in other habitats. From this evidence it appears that both as a habitat for invertebrates and fishes and as a major organic carbon source in nearshore areas, eelgrass is a key feature in the production and diversity of nearshore fishes. A substantial reduction of the eelgrass habitat or decrease in productivity would alter the community structure and energy flow in the nearshore zone. Petroleum spills are likely to inhibit the rate processes and structure of detritus-based food webs. Adsorption of petroleum hydrocarbons by detrital particles will introduce hydrocarbons directly into the base of this food web. High concentrations of unweathered petroleum adsorbed by detritus may inhibit bacterial decomposition, although some bacteria which can utilize petroleum will probably be enhanced. But through the combined processing of detritus and petroleum by bacteria, hydrocarbon components or metabolites can be transferred to detritivorous epibenthic organisms and ultimately to the nearshore fish that prey on them. This process of active pollutant transfer is, however, mediated, often in a very short time, by depuration and metabolic losses of the toxic components.

One of the more important contributions of the nearshore fish investigations along the strait has been the first comprehensive survey of the intertidal (tidepool and beneath-rock) fish assemblages of rocky and cobble habitats. These habitats make up a large proportion of the shoreline in the Strait of Juan de Fuca and northern Puget Sound region. Although the rocky intertidal may not be as vulnerable to the long-term effects of an oil spill as the soft-sediment habitats, the fish assemblages and the prey resources are extremely vulnerable to short-term effects because of their confinement in pools and beneath rocks at low tide. Unlike sand and gravel beaches where the fish move up and down the beach with the tide, rocky intertidal fishes would be constantly subjected to high concentrations of petroleum hydrocarbons as they accumulated in the intertidal zone with each tidal influx. The prey resources of the rocky intertidal fishes, mainly epibenthic crustaceans associated with algae, would also suffer high mortalities during the initial event. Because of weathering of petroleum and lack of incorporation into the substrate in rocky intertidal habitats, the long-term recovery would probably be quicker than in the soft-bottom eelgrass habitats.

Of all the habitats studied, the exposed sand-gravel beaches (e.g., Dungeness Spit, West Beach) are probably the least vulnerable to oil spills. Because of wave action, most of the fish species which occur at these sites are rather transient and are often virtually absent during winter. The weathering of petroleum would be more rapid in habitats exposed to wave action than in the protected habitats. However, juvenile salmon, principally coho and chinook, may be abundant in the exposed habitats from spring through late summer. As mentioned previously, these neritic fishes may be able to detect and avoid contaminated waters, but it is conceivable that an extensive petroleum spill could reduce the populations of prey organisms important to the juvenile salmon (especially mysids) and transfer petroleum hydrocarbons to an economically important group of fish utilized by man.

The time of year of an oil spill may determine the extent of its effects on the nearshore fish assemblages. Midwinter through late summer appears to be critical from several standpoints. Fish eggs and larvae are most abundant in the neritic waters between February and May and the survival rate of entire year classes could be affected by a petroleum spill at that time. This period is also an important time for the decomposition of detritus in the nearshore zone and the corresponding increase in epibenthic zooplankton; reduction of this detrital source, inhibition of the decomposition process, or reduction of the first reproductive generation of epibenthic crustaceans would tend to depress or delay production of many important prey resources for the nearshore fish. Spring and summer represent the periods of maximum density and standing crop of nearshore fish, and more important, the period of recruitment of many species to nearshore habitats. Their dependence on these habitats for growth and protection from predation emphasizes the potential for deleterious effects from the introduction of petroleum into the nearshore ecosystem.

SECTION 5

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SECTION 6

APPENDICES

Appendix 6.1 Dates of beach seine, townet, and intertidal sampling.

Beach seine collection dates (month-day)

Kydaka Beach
76-77: 5-17, 8-10, 1-15
77-78: 5-7, 8-28, 10-16
78-79: 5-8, 8-18, 1-12

Twin Rivers
76-77: 5-16, 8-9, 10-26, 1-18
77-78: 5-5, 8-27, 10-16, 1-21
78-79: 5-9, 8-19, 10-17, 1-13

Morse Creek
76-77: 5-15, 8-8, 10-25, 1-17
77-78: 5-6, 8-26, 10-13, 1-22
78-79: 5-6, 8-14, 10-16, 1-8

Dungeness Spit
76-77: 5-13, 8-6, 10-23, 1-14
77-78: 5-3, 8-24, 1-20
78-79: 5-7, 8-15, 10-18, 1-10

Jamestown-Port Williams
76-77: 5-12, 8-5
77-78: 5-4, 8-25, 10-17, 1-24
78-79: 5-11, 8-16, 10-15, 1-9

Beckett Point
76-77: 5-14, 8-7, 10-24, 1-19
77-78: 5-8, 8-23, 10-15, 1-23
78-79: 5-10, 8-17, 10-14, 1-11

Alexander's Beach
77-78: 5-17, 8-26, 10-18, 2-22

West Beach
77-78: 5-18, 8-23, 10-17, 2-23

Townet collection dates (month-day)

Kydaka Beach
76-77: 5-22, 8-13, 10-2, 12-30
77-78: 5-14, 8-31, 10-22, 12-29
78-79: 5-14, 8-26, 10-22

Pillar Point
76-77: 5-22, 8-13, 10-2, 12-30
77-78: 5-14, 8-31, 10-22, 12-29
78-79: 5-14, 8-26, 10-22

Twin Rivers
76-77: 5-23, 8-13, 10-2, 12-30
77-78: 5-13, 8-31, 10-22, 12-29
78-79: 5-14, 8-26, 10-22

Morse Creek
76-77: 5-23, 8-14, 10-3, 12-29
77-78: 5-15, 8-30, 10-21, 12-28
78-79: 5-15, 8-27, 10-21

Dungeness Spit
76-77: 5-24, 8-14, 10-3, 12-29
77-78: 5-15, 8-30, 10-21, 12-28
78-79: 5-15, 8-27, 10-21

Jamestown-Port Williams
76-77: 5-24, 8-14, 10-3, 12-29
77-78: 5-15, 8-30, 10-21, 12-28
78-79: 5-15, 8-27, 10-21

Beckett Point
76-77: 5-24, 8-14, 10-3, 12-29
77-78: 5-15, 8-30, 10-21, 12-28
78-79: 5-15, 8-27, 10-21

Alexander's Beach
77-78: 5-16, 9-1, 10-24, 12-30

West Beach
77-78: 5-16, 9-1, 10-24, 12-30

Appendix 6.1 (Contd.)

Tidepool collection dates (month-day)

Neah Bay
77-78: 6-2, 8-15
78-79: 4-27, 6-7, 6-25, 8-19, 11-16

Slip Point
77-78: 11-19, 2-14, 4-8, 5-22, 7-31, 9-16, 11-14, 12-11
78-79: 1-9, 2-6, 3-6, 4-26, 5-24, 6-22, 7-5, 8-18, 11-15

Twin Rivers
77-78: 11-21, 2-13, 4-9, 5-20, 6-1, 7-4, 7-29, 8-1, 8-16, 11-13, 12-10
78-79: 1-8, 2-5, 3-5, 4-25, 5-26, 6-5, 6-21, 6-24, 8-17, 11-14

Observatory Point
77-78: 2-12, 4-7, 5-21, 5-31, 7-3, 7-28, 8-14, 11-12, 12-9
78-79: 1-7, 2-4, 3-4, 4-24, 4-28, 5-22, 6-4, 6-19, 8-15, 11-13

Morse Creek
77-78: 2-11, 4-10, 5-19, 5-30, 7-1, 7-26, 8-13, 11-11, 12-8
78-79: 1-6, 2-3, 3-3, 4-29, 6-18

North Beach
77-78: 12-20, 4-6, 5-18, 6-30, 8-12, 11-10
78-79: 4-23, 5-21

Appendix 6.2 Oceanographic data from beach seine, townet, and tidepool collections: a. Beach seine temperature (°C) summary.

	Spring			Summer			Autumn			Winter			Totals					
													76/77		77/78		78/79	
Location	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Kydaka Beach	11.5	11.6	10.5	10.4	11.0	12.0	--	9.3	--	8.5	--	7.0	10.1	1.24	10.6	1.19	9.8	2.57
Twin Rivers	13.5	9.2	14.0	12.2	11.5	12.5	7.7	9.0	10.2	9.0	8.0	6.2	10.6	2.34	9.4	1.48	10.7	3.40
Morse Creek	11.5	10.0	10.5	10.6	11.3	12.0	8.3	10.0	10.0	8.5	7.5	6.5	9.7	1.36	9.7	1.59	9.8	2.33
Dungeness Spit	9.6	9.2	11.0	10.4	11.2	12.5	8.4	--	9.0	7.5	9.0	6.5	9.0	1.11	9.8	1.22	9.8	2.60
Jamestown - Port Williams	10.4	10.0	14.5	12.6	11.5	13.0	--	10.0	10.3	--	7.0	6.0	11.5	1.10	9.6	1.89	11.0	3.73
Beckett Point	13.5	13.6	12.0	13.8	5.9	14.0	9.8	10.1	10.0	7.7	7.0	6.0	11.2	2.56	10.2	3.30	10.5	3.42
West Beach		11.5			12.0			10.0			9.0				10.6	1.38		
Alexander's Beach		13.4			13.6			9.1			8.0				11.0	2.89		
$\bar{X}$	11.7	11.1	12.1	11.7	11.7	12.7	8.6	9.6	9.9	8.2	7.9	6.4						
SD	1.45	1.76	1.77	1.29	0.88	0.75	0.77	0.49	0.52	0.62	0.84	0.38						

Appendix 6.2 (Contd.) b. Beach seine salinity (ppt) summary.

	Spring			Summer			Autumn			Winter			Totals					
													76/77		77/78		78/79	
Location	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Kydaka Beach	31.3	29.9	30.4	30.8	31.5	30.9	--	32.0	--	30.2	--	31.1	30.8	0.45	31.3	1.10	30.8	0.36
Twin Rivers	26.8	19.4	28.0	29.6	31.0	30.3	29.7	30.2	--	23.2	14.3	29.2	27.3	2.65	23.7	8.21	29.2	1.15
Morse Creek	31.4	31.4	30.2	28.8	29.7	30.1	31.2	30.9	--	30.7	27.2	31.3	30.5	1.03	27.3	1.87	30.5	0.67
Dungeness Spit	31.3	31.3	31.5	30.4	31.1	30.1	31.3	--	--	30.9	29.7	32.2	31.0	0.37	30.7	0.87	31.3	1.07
Jamestown - Port Williams	--	24.4	12.1	--	27.1	27.3	--	29.9	--	--	23.3	31.3	--		26.2	2.95	23.6	10.13
Beckett Point	30.2	31.1	29.9	30.7	29.7	32.0	31.2	31.4	--	30.8	30.1	31.9	30.7	0.36	30.6	0.81	31.3	1.18
West Beach		29.6			29.3			30.5			28.6				29.5	0.79		
Alexander's Beach		26.9			29.7			30.6			24.2				27.9	2.90		
$\bar{X}$	30.2	28.0	27.0	30.1	29.9	30.1	30.9	30.8	--	29.6	25.3	31.2						
SD	1.76	4.25	7.40	0.76	1.39	1.56	0.67	0.72	--	2.99	5.52	1.05						

Appendix 6.2 (Contd.) c. Beach seine dissolved oxygen (% saturation) summary.

Location	Spring			Summer			Autumn			Winter			Total					
	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77 $\bar{x}$	76/77 SD	77/78 $\bar{x}$	77/78 SD	78/79 $\bar{x}$	78/79 SD
Kydaka Beach	109.0	72.4	76.4	--	87.1	112.6	--	94.0	--	101.3	--	72.3	105.2	3.90	84.5	11.03	87.1	22.18
Twin Rivers	113.0	64.7	128.7	71.9	54.9	106.2	107.1	109.2	--	100.8	98.0	102.5	98.2	15.79	81.7	26.01	112.47	14.18
Morse Creek	95.0	59.5	140.5	84.9	45.7	139.1	89.8	106.9	--	94.5	106.7	87.9	91.1	4.09	79.7	31.80	122.5	29.97
Dungeness Spit	110.0	103.5	154.1	107.2	112.2	131.7	58.5	--	--	98.0	117.1	94.5	93.4	20.65	110.9	6.89	126.77	30.10
Jamestown - Port Williams	116.0	106.5	128.6	93.8	76.2	90.8	--	78.8	--	--	95.4	91.0	104.9	11.10	89.2	14.32	103.47	21.77
Beckett Point	153.0	156.0	144.6	104.1	66.5	140.2	64.2	91.1	--	82.6	63.0	78.8	101.5	32.64	94.2	43.09	121.2	36.79
West Beach		113.5			94.0			--			101.1				102.9	9.87		
Alexander's Beach		140.6			131.9			--			101.1				124.5	20.75		
$\bar{x}$	116.0	102.1	128.8	92.4	83.6	120.1	80.4	96.0	--	95.4	97.5	87.8						
SD	17.81	35.12	27.67	12.92	28.98	20.04	19.25	12.42	--	6.06	16.78	10.89						

Appendix 6.2 (Contd.) d. Townet surface temperature (°C) summary.

Location	Spring			Summer			Autumn			Winter			Total					
	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77 $\bar{x}$	76/77 SD	77/78 $\bar{x}$	77/78 SD	78/79 $\bar{x}$	78/79 SD
Kydaka Beach	9.4	8.2	9.0	9.5	13.2	12.4	9.0	8.2	8.9	8.5	7.1	5.8	9.1	0.45	9.2	2.73	9.0	2.70
Pillar Point	8.6	8.4	8.6	9.8	9.4	12.0	8.5	8.6	9.1	8.5	7.2	5.9	8.9	0.59	8.4	0.91	8.9	2.50
Twin Rivers	8.9	8.5	8.8	10.7	9.4	12.0	9.7	8.1	8.7	7.9	7.4	5.2	9.3	1.19	8.4	0.83	8.7	2.78
Morse Creek	8.4	8.8	9.8	10.0	9.4	12.8	9.6	8.4	8.8	7.5	7.0	5.9	8.9	1.14	8.4	1.02	9.3	2.85
Dungeness Spit	9.5	8.5	9.4	10.0	9.3	10.7	9.3	8.5	8.9	7.7	6.2	--	9.1	0.99	8.1	1.34	917	0.93
Jamestown-Port Williams	9.3	8.9	8.9	10.0	10.1	10.0	8.9	8.6	9.1	7.1	6.7	5.8	8.8	1.23	8.6	1.41	8.5	1.83
Beckett Point	12.4	10.2	9.4	13.5	12.1	10.7	10.8	9.7	9.7	7.3	6.1	5.6	11.0	2.70	9.5	2.51	8.9	2.14
West Beach		8.8			10.6			9.6			7.1				8.9	1.66		
Alexander's Beach		8.9			10.2			9.8			6.8				8.9	1.52		
$\bar{x}$	9.5	8.8	9.1	10.5	10.4	11.5	9.5	8.8	9.0	7.8	6.8	5.7						
SD	1.34	0.50	0.62	1.37	1.37	1.06	0.60	0.65	0.33	0.55	0.44	0.27						

Appendix 6.2 (Contd.) e. Townet surface salinity (ppt) summary.

	Spring			Summer			Autumn			Winter			Total 76/77		Total 77/78		Total 78/79	
Location	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Kydaka Beach	32.6	33.1	31.6	32.4	33.1	32.2	32.6	33.0	33.4	28.3	32.7	32.3	31.5	2.12	33.0	0.19	32.4	0.75
Pillar Point	32.5	32.8	32.9	32.2	33.6	32.6	32.7	32.3	34.6	31.6	32.8	32.4	32.3	0.48	32.8	0.45	33.1	1.04
Twin Rivers	31.9	33.1	32.8	31.9	33.6	32.5	32.6	32.9	34.2	31.5	33.1	33.1	32.0	0.46	33.1	0.21	33.2	0.76
Morse Creek	28.1	31.6	30.9	31.8	33.4	32.2	32.2	32.9	32.3	31.8	33.0	32.9	31.0	1.93	32.7	0.70	32.1	0.84
Dungeness Spit	31.8	32.4	32.1	32.2	33.3	32.3	32.5	33.3	32.0	32.7	33.2	--	32.1	0.76	33.1	0.44	32.1	0.15
Jamestown-Port Williams	30.5	32.3	32.2	31.7	32.8	32.5	32.7	32.8	29.6	32.2	32.7	32.1	31.8	0.94	32.7	0.26	31.6	1.36
Beckett Point	31.3	32.2	32.0	31.6	32.4	32.3	32.0	32.5	32.2	33.1	32.6	32.1	31.7	0.32	32.4	0.17	32.2	0.13
West Beach		31.2			31.4			31.4			30.9				31.2	0.21		
Alexander's Beach		31.1			31.6			31.3			31.0				31.2	0.18		
$\bar{x}$	31.1	32.2	32.1	32.0	32.7	32.3	32.5	32.5	32.6	31.6	32.6	32.5						
SD	1.54	0.76	0.49	0.30	0.09	0.13	0.27	0.71	1.67	1.57	0.97	0.42						

Appendix 6.2 (Contd.) f. Townet dissolved oxygen (% saturation) summary.

	Spring			Summer			Autumn			Winter			Total 76/77		Total 77/78		Total 78/79	
Location	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Kydaka Beach	97.0	92.3	87.5	75.3	105.5	106.9	68.0	71.3	100.1	101.6	88.2	85.0	84.5	2.12	89.3	14.10	94.9	10.39
Pillar Point	86.0	100.6	90.9	82.2	74.5	102.1	64.9	71.5	100.0	98.3	86.3	71.0	81.9	0.48	83.2	13.23	91.0	14.19
Twin Rivers	90.0	88.6	93.6	84.0	74.1	65.2	75.9	63.2	100.0	95.5	83.3	29.0	86.6	0.46	77.3	11.15	72.0	32.38
Morse Creek	86.0	92.9	104.3	82.6	62.7	100.0	69.9	79.4	100.0	87.6	84.2	76.0	81.5	1.93	79.8	12.70	95.1	16.81
Dungeness Spit	84.0	89.8	87.1	72.6	66.3	86.0	76.6	60.6	100.0	80.3	81.3	--	75.9	0.76	82.0	11.28	90.4	8.49
Jamestown-Port Williams	94.0	97.9	81.0	76.0	68.9	74.0	62.8	65.2	100.0	70.3	85.2	79.0	70.0	0.94	79.3	15.14	83.7	11.34
Beckett Point	136.0	137.0	95.0	116.0	92.6	81.8	92.3	104.3	102.2	81.9	89.6	84.0	106.6	0.32	105.9	21.7	90.0	9.57
West Beach		85.6			--			71.3			82.5				79.8	7.52		
Alexander's Beach		92.7			68.9			80.2			86.0				82.0	10.09		
$\bar{x}$	96.1	97.5	91.5	84.3	76.7	89.6	71.3	74.1	100.3	88.0	85.2	68.7						
SD	10.19	15.50	7.19	14.86	14.73	16.57	10.27	13.13	0.83	9.10	2.68	20.90						

Appendix 6.3 Biological data from beach seine collections, 1976-1978:
a. Summary of species richness (number of species).

	Spring			Summer			Autumn			Winter			Total					
													76/77		77/78		78/79	
Location	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Kydaka Beach	7	4	7	13	10	13	--	10	--	7	--	4	9.0	3.5	8.0	3.5	8.0	4.6
Twin Rivers	10	16	12	18	16	16	12	13	16	12	14	8	13.0	3.5	14.8	1.5	13.0	3.8
Morse Creek	9	11	7	15	15	21	11	19	20	12	7	--	11.8	2.5	13.0	5.2	16.0	7.8
Dungeness Spit	8	5	12	13	12	12	17	--	17	5	5	11	10.8	5.3	7.3	4.0	13.0	2.7
Jamestown-Port Williams	7	16	17	6	17	14	--	16	17	--	18	9	6.5	0.7	16.8	1.0	14.3	3.8
Beckett Point	19	16	23	30	27	28	25	31	22	30	17	22	26.0	5.2	22.8	7.4	23.8	2.9
West Beach		14			16			17			13				15.0	1.8		
Alexander's Beach		10			11			13			10				11.0	1.4		
$\bar{X}$	10.0	11.5	13.0	15.8	15.5	17.3	16.3	17.0	18.4	13.2	12.0	10.8						
SD	4.6	4.9	6.2	8.0	5.3	6.1	6.4	6.9	2.5	9.9	4.9	6.8						

Appendix 6.3 (Contd.) b. Summary of fish density (fish/m^2).

	Spring			Summer			Autumn			Winter			Total					
													76/77		77/78		78/79	
Location	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Kydaka Beach	0.05	0.01	0.05	1.75	18.36	0.14	--	0.05	--	0.02	--	0.04	0.61	0.99	6.14	10.58	0.08	0.06
Twin Rivers	0.13	0.02	0.07	0.74	0.58	0.48	0.19	0.64	0.20	0.14	0.12	0.04	0.30	0.29	0.34	0.32	0.20	0.20
Morse Creek	0.01	0.02	0.05	0.38	0.13	0.02	0.03	0.15	0.24	0.02	0.03	--	0.11	0.18	0.08	0.07	0.10	0.12
Dungeness Spit	0.01	0.01	0.13	0.76	0.11	0.12	0.08	--	0.17	0.01	0.01	0.02	0.22	0.36	0.04	0.06	0.11	0.06
Jamestown-Port Williams	0.04	0.07	0.12	0.10	0.64	0.49	--	1.81	0.47	--	0.40	0.06	0.07	0.04	0.73	0.76	0.29	0.23
Beckett Point	0.50	0.03	0.06	1.18	1.74	0.98	1.66	0.30	1.12	2.03	0.34	0.44	1.34	0.66	0.60	0.77	0.65	0.49
West Beach		0.02			0.07			0.17			0.54				0.20	0.24		
Alexander's Beach		0.73			0.33			0.75			0.12				0.48	0.31		
$\bar{X}$	0.12	0.11	0.08	0.82	2.75	0.37	0.49	0.55	0.44	0.44	0.22	0.12						
SD	0.19	0.25	0.04	0.59	6.33	0.36	0.78	0.61	0.40	0.89	0.20	0.18						

Appendix 6.3 (Contd.) c. Summary of fish standing crop (g/m^2).

													Total					
	Spring			Summer			Autumn			Winter			76/77		77/78		78/79	
Location	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Kydaka Beach	0.39	0.35	1.28	6.39	52.07	1.66	--	1.49	--	1.23	--	1.58	2.67	3.25	17.97	29.54	1.51	0.20
Twin Rivers	0.32	1.49	4.32	7.06	7.08	17.92	17.85	5.67	6.65	12.61	9.31	8.12	9.46	7.52	5.89	3.29	9.25	5.99
Morse Creek	1.70	3.18	0.27	2.03	2.17	2.83	4.09	1.95	3.86	0.36	0.20	--	2.05	1.54	1.88	1.24	2.32	1.85
Dungeness Spit	0.33	0.08	0.43	2.89	0.48	0.12	1.52	--	3.36	0.11	0.04	0.22	1.21	1.28	0.20	0.24	1.03	1.56
Jamestown-Port Williams	0.12	4.09	0.20	0.38	5.47	0.95	--	8.93	2.58	--	1.01	0.28	0.25	0.18	4.88	3.28	1.00	1.10
Beckett Point	10.35	1.61	0.48	6.36	12.16	0.98	17.00	3.78	10.36	13.25	2.31	1.81	11.74	4.50	4.97	4.88	3.41	4.67
West Beach		4.78			3.30			4.38			1.74				3.55	1.36		
Alexander's Beach		1.29			1.91			7.92			1.43				3.14	3.20		
$\bar{X}$	2.20	2.11	1.16	4.19	10.58	4.08	10.12	4.87	5.36	5.51	2.29	2.40						
SD	4.03	1.72	1.59	2.78	17.17	6.84	8.51	2.82	3.19	6.79	3.20	3.28						

Appendix 6.4 Biological data from townet collections, 1976-1978: a. Summary of species richness (number of species).

													Total					
	Spring			Summer			Autumn			Winter			76/77		77/78		78/79	
Location	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Kydaka Beach	5	4	11	2	6	7	6	3	6	3	1	2	4.0	1.83	2.3	1.5	6.5	3.7
Pillar Point	11	4	11	5	4	9	7	6	7	4	2	0	6.7	3.10	4.0	1.6	6.8	4.8
Twin Rivers	10	4	9	13	3	2	7	6	1	6	0	0	9.0	3.16	3.3	2.5	3.0	4.1
Morse Creek	19	5	12	10	8	6	10	11	3	5	2	3	11.0	5.83	6.5	3.9	6.0	4.2
Dungeness Spit	9	6	10	12	8	8	9	12	3	6	4	0	9.0	2.45	7.5	3.4	5.3	4.6
Jamestown-Port Williams	10	6	9	9	9	6	12	4	4	5	3	3	9.0	2.94	5.5	2.7	5.5	2.6
Beckett Point	9	4	13	12	6	7	14	9	1	4	5	1	9.8	4.35	6.0	2.2	5.5	5.7
West Beach		5			12			4			6				6.8	3.6		
Alexander's Beach		13			11			9			6				9.7	3.0		
$\bar{X}$	10.4	5.7	10.7	9.0	7.4	6.4	9.3	7.1	3.6	4.7	3.2	1.3						
SD	4.2	2.9	1.5	4.1	3.0	2.2	2.9	3.3	2.3	1.1	2.2	1.4						

Appendix 6.4 (Contd.) b. Summary of fish density (fish/m^3).

													Total					
	Spring			Summer			Autumn			Winter			76/77		77/78		78/79	
Location	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Kydaka	0.01	0.32	0.04	<0.01	0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.08	0.16	0.01	0.02
Pillar Point	0.01	0.01	0.03	0.03	1.66	0.13	0.01	<0.01	0.01	0.01	<0.01	0.0	0.01	0.01	0.42	0.83	0.04	0.06
Twin Rivers	0.11	0.90	0.72	0.20	0.01	<0.01	0.01	0.01	<0.01	<0.01	0.0	0.0	0.09	0.10	0.23	0.45	0.18	0.36
Morse Creek	0.09	0.76	0.09	<0.01	5.28	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.02	0.04	1.51	2.54	0.02	0.04
Dungeness Spit	0.03	0.41	0.41	0.04	0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	0,11	0.20	0.11	0.20
Jamestown-Port Williams	0.02	0.12	0.07	0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.04	<0.06	0.02	0.03
Beckett Point	0.09	0.01	0.03	0.30	0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	0.12	0.01	0.01	0.01	0.01	0.01
West Beach		0.01			0.23			<0.01			<0.01				0.06	0.11		
Alexander's Beach		0.04			0.32			<0.03			<0.01				0.10	0.15		
$\bar{X}$	0.05	0.29	0.20	0.08	0.84	0.02	0.01	<0.01	<0.01	0.01	<0.01	<0.01						
SD	0.44	0.34	0.27	0.12	1.75	0.05	0.02	<0.01	<0.01	0.01	<0.01	<0.01						

Appendix 6.4 (Contd.) c. Summary of fish standing crop (g/m^3).

	Spring			Summer			Autumn			Winter			Total					
													76/77		77/78		78/79	
Location	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	76/77	77/78	78/79	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Kydaka Beach	<0.01	0.02	<0.01	<0.01	0.02	0.04	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	0.02
Pillar Point	0.01	<0.01	<0.01	0.16	2.29	0.40	0.01	<0.01	0.04	<0.01	<0.01	<0.01	0.05	0.07	0.57	1.14	0.11	0.19
Twin Rivers	0.01	0.04	<0.01	0.27	0.01	0.02	0.02	0.03	<0.01	0.01	0.0	0.0	0.08	0.13	0.02	0.02	<0.01	<0.01
Morse Creek	0.01	0.03	0.01	0.01	12.31	0.01	0.04	0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.01	3.09	6.15	<0.01	<0.01
Dungeness Spit	<0.01	0.02	0.01	0.29	0.32	0.01	0.08	0.04	0.01	<0.01	<0.01	0.0	0.09	0.14	0.09	0.15	<0.01	<0.01
Jamestown-Port Williams	0.03	0.01	<0.01	0.17	0.13	0.18	0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.05	0.08	0.04	0.06	0.05	0.09
Beckett Point	0.04	0.01	0.02	0.92	0.03	0.02	0.38	0.03	<0.01	<0.01	0.01	<0.01	0.34	0.43	0.02	0.02	0.01	0.01
West Beach		<0.01			0.93			0.07			<0.01				0.26	0.45		
Alexander's Beach		0.03			1.50			0.20			0.02				0.44	0.71		
$\bar{X}$	0.02	0.02	<0.01	0.26	2.06	0.10	0.08	0.05	0.01	<0.01	<0.01	<0.01						
SD	0.01	0.01	<0.01	0.31	3.92	0.15	0.14	0.06	0.01	<0.01	<0.01	<0.01						

Appendix 6.5 Summary of biological data from intertidal collections, 1977-1978: a. Species of fish collected at each site; residents (o), transients (*).

Species	Neah Bay	Slip Point	Twin Rivers	Observatory Point	Morse Creek	North Beach
Gobiesox maeandricus	o	o	o	o	o	o
Artedius fenestralis		*		*		*
A. harringtoni				*		
A. lateralis	o	o	o	o	o	*
Ascelichthys rhodorus	o	o	o	o	o	o
Blepsias cirrhosus				*		
Clinocottus acuticeps	o	o	o	o	o	o
C. embryum	o	o		o		*
C. globiceps	o	o		o	*	*
Enophrys bison			*	*		*
Hemilepidotus hemilepidotus	*	*				
Oligocottus maculosus	o	o	o	o	o	o
O. rimensis	o	o		o	*	*
O. snyderi	o	o	*	o	*	
Anoplarchus purpurescens	o	o	o	o	o	o
Phytichthys chirus	o	o		o		
Xiphister atropurpureus	o	o	o	o	*	*
X. mucosus	o	o	o	o	*	
Apodichthys flavidus	o	o	o	o	o	*
Pholis laeta	o	o	o	o	o	o
P. ornata				*		
Liparis florae	o	o	o	o	o	*
L. cyclopus		*	*	*		*
L. rutteri					*	

Appendix 6.5 (Contd.) b. Density of fish. Above, density of fish in tidepools (number/m^2); below, density of fish beneath rocks (number/rock).

	Feb		Apr		May		Jul		Aug		Nov	
Location	77	78	77	78	77	78	77	78	77	78	77	78
North Beach	--	--	--	10.3	3.0	18.8	14.1	--	7.2	--	20.3	40.0
	--	--	2.9	0.4	0.9	0.6	0.1	--	0.6	--	0.5	1.7
Morse Creek	20.0	11.8	14.9	15.4	7.5	--	34.4	25.3	35.0	--	10.7	30.8
	1.0	1.3	2.1	0.7	2.2	--	1.4	2.3	4.6	--	1.8	9.0
Observatory Point	28.0	28.5	27.5	21.4	23.3	78.9	18.8	26.1	47.8	23.3	60.7	22.8
	12.0	4.7	6.8	1.6	2.6	1.8	2.5	3.3	5.7	--	3.9	1.3
Twin Rivers	23.2	20.4	51.1	15.3	43.3	32.2	21.1	--	23.3	32.0	16.7	35.1
	1.1	0.6	2.1	1.4	0.9	2.7	2.5	--	--	--	0.5	0.6
Slip Point	13.0	51.0	15.2	17.4	11.9	10.4	17.8	28.4	27.9	43.3	24.9	9.4
	1.6	2.5	1.6	1.9	2.1	--	3.5	3.7	1.7	--	6.7	1.1
Neah Bay	--	--	--	11.3	65.8	37.8	--	--	1.3	22.9	--	9.1
	--	--	--	--	--	--	--	--	--	--	--	--

Appendix 6.5 (Contd.) c. Standing crop of fish. Above, standing crop of tidepool fish (g/m^2); below, standing crop of fish beneath rocks (g/rock).

Location	Feb		Apr		May		Jul		Aug		Nov	
	77	78	77	78	77	78	77	78	77	78	77	78
North Beach	--	--	--	18.7	10.4	30.1	30.0	--	4.4	--	64.6	126.7
	--	--	9.4	0.6	3.7	4.5	0.4	--	3.0	--	0.9	9.2
Morse Creek	32.1	22.8	25.9	18.8	11.3	--	98.2	78.8	92.2	--	11.9	53.2
	2.9	3.1	10.5	5.6	12.8	--	2.2	10.3	33.8	--	5.0	12.3
Observatory Point	31.9	22.6	48.6	37.0	41.5	114.0	44.0	22.5	73.5	52.1	66.1	48.4
	28.8	12.8	17.1	1.5	10.2	2.4	10.0	25.2	19.2	--	9.3	28.9
Twin Rivers	33.7	19.5	60.8	10.4	62.9	37.3	25.8	--	6.8	33.0	29.4	64.7
	3.6	0.6	12.7	47.1	5.6	41.0	29.2	--	--	--	2.5	5.7
Slip Point	29.4	57.9	21.9	30.2	31.5	50.9	80.9	33.3	47.2	98.1	79.5	18.7
	10.9	15.0	12.4	14.3	12.4	--	16.0	18.5	8.2	--	10.7	11.3
Neah Bay	--	--	--	33.0	107.0	90.7	--	--	1.5	73.7	--	21.4
	--	--	--	--	--	--	--	--	--		--	

Appendix 6.6 Summary of macroinvertebrates collected incidentally to beach seine and townet samples: a. May 1976-January 1977. B = Beckett Point, D = Dungeness Spit, J = Jamestown, K = Kydaka Beach, M = Morse Creek, P = Pillar Point, T = Twin Rivers.

Organism	Beach seine	Townet
Phylum Cnidaria		
Class Hydrozoa		
Aequorea aequorea		J
Hydromedusae sp.		P,J,D,B
Medusa	K,D	
Class Anthozoa		
Anthopleura elegantissima	B	
Phylum Ctenophora		
Beroë spp.		D
Phylum Platyhelminthes		
Class Turbellaria		
Turbellaria sp.	B	
Phylum Nemertea		
Nemertea sp.	J	
Phylum Mollusca		
Class Gastropoda		
Amphissa columbiana	B	
Littorina scutulata	M,B	
L. sitkana	B	
Margarites pupillus	B	
Nassarius mendicus	B	
Pollinices lewisi	B	
Hermissenda crassicornus	M,B	
Melibe leonina	M,B	
Class Bivalvia		
Clinocardium nuttalli	B	
Cryptomya californica	J	
Class Cephalopoda		
Octopus sp.	B	
O. dofleini	K	
Phylum Annelida		
Class Polychaeta		
Glycera capitata		J
Platynereis bicanaliculata	J,B	P
Polychaeta sp.		K,T
Polynoidea sp.		J
Tomopteris septentrionalis		P,D
Phylum Arthropoda		
Class Crustacea		
Order Mysidacea		
Acanthomysis davisi	M	T
A. macropsis		K,P,T,D,M,J
A. nephrophthalma		P,D,M
A. sculpta	T,D,M	T,D,M,J
A. sculpta var nuda	D,M	D,J
Archaeomysis grebnitzkii	D,M	K,P,T,D,M,J
Boreomysis microps		T

Appendix 6.6 (Contd.) a. May 1976-January 1977.

Organism	Beach seine	Townet
Mysis oculata		T,D
Neomysis sp.		P,D
N. kadiakensis		K,P,T
N. mercedis		T
N. rayii	D,M	K,P,T,D,M
Proneomysis wailesi	D	T,D,J
Mysid sp.	K,D	
Order Cumacea		
Diastyis sp.		T
Order Isopoda		
Argeia pugettensis	K,D,T	
Bopyroides hippolytes	B	
Gnorimosphaeroma sp.		J
G. oregonensis	K,D,M	J,D,M,T
Idotea fewkesi	D,M,J,B	
I. rufescens		D
Ligia pallasi	M	
Pentidotea montereyensis	K,M	
P. resecata	D,J,B	J,P,D,M,T
P. wosnesenskii	K,T,M	D
Rocinela belliceps	T,M	J,D,K,M,T
Synidotea angulata	J	
S. bicuspida		K,P,D,J,B
Tecticeps pugettensis		D
Order Amphipoda		
Amphelisca agassizi		D
A. pugetica	D	
Amphithoë sp.		P
A. humeralis	B	J,D
A. lacertosa	T,J,B	
Anisogammarus confervicolus	T	
A. pugettensis	J,M	
Anonyx laticoxae	D,M,B	J,D,K,M
Atylus collingi		T
A. tridens	T,D,M,B	M,J,D,K,P,B,T
Caprella leviuscula	D	
Corophium brevis		M
Gammaridae sp.	P,B	
Hyale plumulosa	B	
Melita dendata	J,B	
Metacaprella kennerlyi	B	
Orchestoidea pugettensis	D	
Pontogenia ivanovi	M	D,M
P. rostrata		D,M
Westwoodilla caecula		D,M
Order Euphausiacea		
Euphausia sp.		T,M
Euphausia pacifica		P
Thysanoessa inermis		P
T. longipes		P
T. raschi		P
T. spinifera		P

Appendix 6.6 (Contd.) a. May 1976-January 1977.

Organism	Beach seine	Townet
Order Decapoda		
Callianassa californiensis		J
Crangon sp.	T	J
C. alaskensis	T,D,M,J,B	J,D,K,P,B,M,T
C. communis	B	
C. franciscorum	D,M	J,D,M,T
C. nigricauda	T,D,M,J,B	D
C. stylirostris	K,T,D,M	J
Eualus avinus	M	J
E. fabricii		T,D,M,J
E. pusiolus	T,B	
E. suckleyi		T
E. townsendi		J
Heptacarpus brevirostris	T,J,B	D
H. kincaidi		M
H. paludicola	J	
H. sitchensis	J,B	
H. stimpsoni	B	
H. stylus	M,B	J,M
H. taylori		J
H. tenuissimus	M,B	K,P,M,T
Pandalus danae	D,B	D,B
P. montagui tridens	B	
P. stenolepis		T,D,M,J
Sclerocrangon alata		D,J
Spirontocaris arcuata	B	
S. snyderi	B	
Upogebia pugettensis	J	D
Cancer magister	K,T,D,M,J,B	
C. oregonensis	M,B	
C. productus	D,B	
Fabia subquadrata		P,D,J
Lophopanopeus bellus	B	
Megalops		J,B
Oregonia gracilis	J,B	
Pagurus armatus	B	
P. beringanus	J,B	
P. granosimanus	B	
P. hirsutiusculus	B	
Petrolisthes eriomerus	B	
Pugettia gracilis	P,M,J,B	
P. producta	J,B	P
P. richii	M,B	
Telmessus cheiragonus	J,B	
Zoea		T,D,J,B
Phylum Echinodermata		
Class Asteroidea		
Evasterias troschelii	D	
Henricia leviuscula	D	
Class Echinoidea		
Dendraster excentricus	B	

Appendix 6.6 (Contd.) b. May 1977-February 1978. A = Alexander's Beach, B = Beckett Point, D = Dungeness Spit, J = Jamestown, K = Kydaka Beach, M = Morse Creek, P = Pillar Point, PW = Port Williams, T = Twin Rivers, W = West Beach. (Note: Jamestown and Port Williams are equivalent sites.)

SPECIES (148 total)	BEACH SEINE (92 spp)	TOWNET (95 spp)
Phylum Cnidaria		
Class Hydrozoa		
Aequorea aequorea	D	D,PW,P
Aurelia aurita	M	
Cyanea capillata	K	M
Gonionemus vertens	J	P
Polyorchis penicillatus		P
Unidentified jellyfish	T	M,B,A,W
Unidentified hydroids		P
Phylum Ctenophora		
Beröe spp.		P,M
Pleurobranchia spp.	B	B,K,A,W
Unidentified ctenophore		T,A
Phylum Nemertinea		
Unidentified nemertean		PW
Phylum Mollusca		
Class Gastropoda		
Aglaja diomedia	B	
Calliostoma ligatum		K
Collisella instabilis		P
Collisella pelta	B	
Haminoea spp.	B	
Haminoea virescens		K,M,A,W
Hermissenda crassicornis	B	
Littorina spp.	J,W	
L. planaxis	J,B	
L. scutulata	B	
L. sitkana		A
Melibe leonina	B	D
Notoacmaea persona	J,W	
Notoacmaea scutum	J	
Nudibranch spp.	B,K	
Philine spp.		PW
Pollinices lewisi	K,B	
Pteropod spp.		PW,W
Thais lamellosa	A,W	
Unidentified snail		P
Class Bivalvia		
Clinocardium nuttalli	J,W	P
Mytilus edulis	B	
Tresus capax	B	

Appendix 6.6 (Contd.) b. May 1977-February 1978.

Class Cephalopoda		
Gonatus fabricii		P,PW,A,W
Loligo opalescens		P,PW,A,W
Octopus spp.		A
Phylum Annelida		
Class Polychaeta		
Flabelligera infundibularis		A
Halosydna brevisetosa		P
Lepidasthenia interrupta		K
Nereis vexillosa	A	
Nereid spp.	B,J	K,A
Nothria elegans		PW
Phyllodocid spp.	B	
Polychaeta spp.	B,A,W	
Tomopteris septentrionalis		P,M,D,W
Class Hirudinea		
Unidentified leech	B	
Phylum Arthropoda		
Class Crustacea		
Order Mysidacea		
Acanthomysis columbiae		W
Acanthomysis davisi		T,M,PW
A. macropsis		K,P,PW,B,W
A. nephrophthalma		T,PW,B
A. pseudomacropsis	W	
A. sculpta	A,W	K,D
Archaeomysis grebnitzkii	W	K,P,M,D,PW,A,W
A. maculata		D,W,M
Mysid spp.	W	
Mysis oculata		PW
Neomysis awatschensis		W
N. kadiakensis		W
N. rayii		K,P,T,M,PW,B,A,W,D
Order Cumacea		
Unidentified spp.	J	P,T,D,PW,A,W
Order Isopoda		
Dynamenella glabra		P
Dynamenella sheari		P
Gnorimosphaeroma oregonensis	M,W	K,M,D,W
Idotea spp.	W	
Idotea fewkesi	T,W	
Pentidotea aculeata	M	
P. montereyensis	M,J,A,W	A
P. resecata	J,B	K,P,T,M,D,PW,A,W
P. wosnesenskii	T,M,J	P
Rocinela belliceps	M,D,A	K,P,M,PW,B,A,W
Rocinela propodialis		T,D,A
Synidotea angulata		P,PW,B
Synidotea bicuspida	W	A,W
Tecticeps pugettensis		M

Appendix 6.6 (Contd.) b. May 1977-February [illegible]

Order Amphipoda		
Amphithöe spp.	W	M
Amphithöe humeralis		K,P
A. lacertosa	J,B,A	
Anonyx laticoxae	K,M,D,J	K,P,M,D,PW,A
Atylus collingi	T	
Atylus tridens	T,M,J,A,W	K,P,M,D,PW,B,A,W
Calliopius spp.	W	
Caprella penantis		T
Gammaridae spp.	K,T,M,J,A,W	K,P,T,M,D,PW,B,A,W
Hyperiidae spp.		D,A
Westwoodilla caecula	W	P,A,W
Order Euphausiacea		
Euphausid spp.		A
Euphausia pacifica		PW,A,W
Thysanoessa raschii		P,D,B,W
T. spinifera		P,T,B,A,W
Order Decapoda		
Callianassa californiensis		PW
C. gigas		PW
Cancer gracilis	B,A,W	
Cancer magister	K,T,M,D,J,B,A,W	
C. oregonensis	D,B	
C. productus	T,J,B	
Crangonidae spp.		PW
Crangon alaskensis	K,T,M,D,J,B,A,W	K,P,M,D,PW,A,W
Crangon nigricauda	K,T,M,J,B	
Crangon stylirostris	K,T,M,D	
Eualus spp.	B	
Eualus avinus	J,A,W	
Eualus fabricii	W	K,M,PW
Eualus pusiolus		PW
Eualus townsendi	B	
Hemigrapsus oregonensis	T	
Heptacarpus brevirostris	K,T,M,D,J,A	A,W
H. flexus	M,B	K,P,T,M,D,PW,B,A,W
H. kincaidi	B	P,M,PW,A
H. paludicola	J	
H. pictus	J	
H. stimpsoni	B	A
H. stylus	B	T,M
H. taylori	T,J,B,A	T,PW
H. tenuissimus	W	
H. tridens	M	M
Hippolyte clarki	J,B	
Hippolytidae spp.	B	K,P,M,D,PW,B
Lebbeus grandimanus	B	P
Megalops		K,M,D,W
Oregonia gracilis	J,B	
Pagurus beringanus	B	
P. capillatus	J,B	

Appendix 6.6 (Contd.) b. May 1977-February 1978.

P. hirsutiusculus	J,B,A,W	
P. granosimanus	J,B,A,W	
Pagurus spp.	M	
Pandalidae spp.	B	K,P,M,D,PW
Pandalus danae	T,M,D,J,B,A	K,M,D,PW,B,W
P. goniurus		K,M,D,A,W
P. montagui tridens	A	P,M,PW,B,A
P. platyceros	B	B
P. stenolepis		M
Pinnotheres pugettensis		P,D
P. taylori		D
Pugettia gracilis	M,J,B,A	D
P. producta	J,B	
P. richii	B,A,W	
Sclerocrangon alata		P,W
Spirontocaris sp.		A
Telmessus cheiragonus	T,J,B	
Upogebia pugettensis	J	
Zoea		T,A,W
Phylum Echinodermata		
Class Asteroidea		
Henricia leviuscula	B	
Leptasterias hexactus	J	
Class Echinoidea		
Dendraster excentricus	W	
Class Ophiuroidea		
Ophiopholis aculeata		P
Phylum Chaetognatha		
Unidentified chaetognaths		P,T,M,PW,A,W
Phylum Bryozoa		
Unidentified bryozoans		K,P

Appendix 6.7 Macroinvertebrate abundance and biomass raw data, May 1976-January 1977: a. Beach seine samples (biomass in g, size in mm).

B E A C H   S E I N E S

Species	May 1976				August 1976				October 1976				January 1977			
		Biomass	Size			Biomass	Size			Biomass	Size			Biomass	Size	
	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range
Site: Jamestown																
Crangon alaskensis	17	5.0	6.4	5.0-9.0												
C. nigricauda	10	5.7	8.3	5.0-10.0	25	23.0	7.3	2.0-13.0								
Heptacarpus brevirostris	9	6.5	7.3	4.0-11.0	2	0.1	3.0	3.0								
H. paludicola	9	1.5	4.5	3.0-4.5												
H. sitchensis	15	1.7	3.1	2.0-4.5												
Upogebia pugettensis	3	0.4			2	2.8			SITE NOT SAMPLED				SITE NOT SAMPLED			
Amphithoë lacertosa	9	1.0			16	1.2										
Anisogammarus pugettensis	1	0														
Melita dendata	3	0														
Idotea fewkesi	1	0														
Pentidotea resecata	6	1.6														
Synidotea angulata	2	0														
Nemertean sp.	1	0														
Polynoidae sp.	10	0.7														
Platynereis bicanaliculata	8	0.4														
Cancer magister					2	--	5.1									
Oregonia gracilis	1	2.1	14.0													
Pugettia gracilis	7	15.2	12.2	8.0-29.0	2	2.8	13.0	10.0-16.0								
Pugettia producta	2	9.5	21.0	18.0-24.0												
Telmessus cheiragonus	19(14)[1]	84.3	22.1	15.0-35.0	7	--	6.0	2.0-7.6								
Cryptomya californica					1	0.2										
Total	137	135.6			57	30.1										

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[1] The first number indicates the total number of individuals collected; the number in parentheses indicates the number of individuals used to calculate the average size or weight.

Appendix 6.7 (Contd.) a. Beach seine samples.

	BEACH SEINES															
	May 1976				August 1976				October 1976				January 1977			
		Biomass	Size			Biomass	Size			Biomass	Size			Biomass	Size	
Species	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range
Site: Dungeness Spit (10% sample size)																
Crangon alaskensis	13	6.7	8.0	6.0-10.0	18	15.9	8.6	4.5-13.0								
C. franciscorum					1	0	8.0		11	18.6	12.1	8.0-15.0				
C. nigricauda	1	0.3	10.5	--	10	10.6	10.1	8.0-15.0					21	43.4	12.5	8.0-17.0
C. stylirostris	48	91.4	10.4	6.0-14.0	18	32.3	10.1	5.0-15.0	27	40.6	12.7	9.0-17.0	12	28.8	14.3	9.0-22.0
Pandalus danae					6	6.5	9.6	8.0-16.0	2	6.6	33.5	32-35				
Ampheliscα pugetica	1	0														
Anonyx laticoxae									6	1.6	20.5		1	0.2	20	
Atylus tridens	1	0			16	0.7			2	0.1	15.0					
Caprella leviuscula	1	0														
Orchestoidea pugettensis	2	0														
Argeia pugettensis	3	0							3	0.2			2	--		
Gnorimosphaeroma oreg.	2	0			38	3.2										
Pentidotea resecata	1	0														
Cancer magister	1	8.7	37		5	--	6.3	2.5-14.0	24(16)	18.7	17.08	10.2-25.0	4	12.0	26	21.0-32.0
C. productus					1	--	10.16									
Pagurus beringanus					1	5.8										
Acanthomysis sculpta					126	2.5							57 49	1.0 0.7	11.72 13.14	10-13 10-15
A. sculpta var. nuda													1	0	11	
Archaeomysis grebnitzkii									1	0						
Neomysis rayii					16	0							1	0.1	22	
Proneomysis wailesi													1	0	17	
Mysid sp.									1	0						
Evasterias troscheli	1	21.6														
Henricia leviuscula					2	38.6										
Medusa sp.													1	0.1	21	
Total	75	128.7			258	116.1			93	86.4			150	86.3		

Appendix 6.7 (Contd.) a. Beach seine samples.

BEACH SEINES

Species	May 1976				August 1976				October 1976				January 1977			
		Biomass	Size			Biomass	Size			Biomass	Size			Biomass	Size	
	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range
Site: Morse Creek																
Crangon alaskensis	2	2.6	9.0	9.0	8	1.9	5.3	5.0-6.5								
C. franciscorum									6	10.5	12.8	9.0-16.0	4	3.3	10.8	9.0-12.0
C. nigricauda	3	7.6	10.7	9.0-12.0	6	6.7	8.1	5.0-12.0								
C. stylirostris	5	9.2	9.7	8.0-15.0	5	6.5	9.1	6.5-13.0	13	16.4	12.2	9.0-17.0	7	13.6	13.1	10.0-15.0
Eualus avinus													4	5.6	11.0	10.0-14.0
Heptacarpus stylus	1	0	4.5													
H. tenuissimus													7	4.3	17.0	15.0-19.0
Anisogammarus pugettensis	3	0.1														
Anonyx laticoxae									1	0.2						
Atylus tridens	37	1.3			1	0.1			1	0.2			1	0.1		
Argeia pugettensis													1	0		
Pontogenia ivanovi													1	0.1		
Gnorimosphaeroma oreg.					1	0										
Idotea fewkesi	5	1.1			1	0.1										
P. wosnesenskii					6	2.1			3	2.0	27.7	23.0-31.0				
Ligia pallasi	1	0.1											1	0.5		
Pentidotea montereycnsis													1	0.5		
Rocinela bellicepa					2	0							1	0.3		
Cancer magister													10(3)	12.6+	12.7	7.62-40.0
C. oregonensis									1	4.5	23					
Pugettia gracilis	1	0.1	6.5													
P. richii													1	0.7	10.0	

Appendix 6.7 (Contd.) a. Beach seine samples.

	BEACH SEINES															
	May 1976				August 1976				October 1976				January 1977			
		Biomass	Size			Biomass	Size			Biomass	Size			Biomass	Size	
Species	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range
Littorina scutulata	1	0														
Acanthomysis davisi	1	0														
A. sculpta					293	8.4										
A. sculpta var. nuda	29	0.5														
Archaeomysis grebnitzkii	20	0.4											4	0.3	19.5	17.0-23.0
Neomysis rayii					5	0										
Hermissenda crassicornis	29	--														
Melibe leonina	41	--														
Total	179	23.0			328	25.8			25	33.8			42	41.4		
Site: Beckett Pt.																
Crangon alaskensis	13	7.1	7.6	3.0-13.0												
C. communis	6	0.7	3.5	2.5-4.5												
C. nigricauda													15	8.0	10.5	5.0-15.0
Eualus pusiolus									1	--			13	4.5	12.9	6.0-11.0
Heptacarpus brevirostris	30	10.3	4.7	2.5-8.5												
H. sitchensis	42	6.3	3.9	2.5-5.0												
H. stimpsoni	41	2.7	3.4	2.0-5.0												
H. stylus	9	1.3	5.0	3.0-7.5												
Heptacarpus tenuissimus	198	18.6	4.2	2.0-6.0									18	4.3	10.8	5.0-17.0
Pandalus danae	7	7.1	11.3	3.0-14.0	14	36.7	29.6	22.0-38.0	13	32.5	32.2	24.0-40.0	19	18	21.8	15.0-35.0
P. montagui tridens	1	0.1	3.0		1	0.2	13.0						9	0.6	9.3	8.0-11.0
Spirontocaris arcuata													1	0.6	12.0	
S. snyderi	1	0.1	4.0													
Amphithoë humeralis	1	0														
A. lacertosa	2	0														

Appendix 6.7 (Contd.) a. Beach seine samples.

	BEACH SEINES															
	May 1976				August 1976				October 1976				January 1977			
			Size				Size				Size				Size	
Species	No.	Biomass (gr)	$\bar{x}$	Range	No.	Biomass (gr)	$\bar{x}$	Range	No.	Biomass (gr)	$\bar{x}$	Range	No.	Biomass (gr)	$\bar{x}$	Range
Anonyx laticoxae													1	0.2		
Atylus tridens	5	0														
Gamm. amphipod sp.	2	0														
Hyale plumulosa	1	0														
Melita dendata	1	0														
Metacaprella kennerlyi	3	0														
Bopyroides hippolytes	1	0														
Idotea fewkesi	1	0														
Pentidotea resecata	20	7.7							2	1.1	37	32.0-42.0	9	3.1	30.7	25.0-40.0
Platynereis bicanaliculata	6	0.1														
Turbellaria sp.													6	0.4		
Cancer magister					3	--	6.8	6.4-7.6	4	--	14.6	10.2-17.8	3(1)	1.9	15.04	8.89-21
C. oregonensis	1	0.2	16.0													
C. productus					1	--							3	2.2	12.3	9.0-15.0
Lophopanopeus bellus	1	0.2	11.0													
Oregonia gracilis	24	25.5	10.2	7.0-14.0	2	0.3	5.0	4.0-6.0					2	0.9	8.0	8.0
Pagurus armatus	3	0.9														
P. beringanus													9	56.3		
P. granosimanus													5	1.1		
P. hirsutiusculus	3	0.2			1	1.3							19	12.7		
Petrolisthes eriomerus													1	0.4	8	
Pugettia gracilis	10	6.0	10.5	6.5-17.0												
P. producta					2	13.4	23.0	22.0-24.0	3	54.8	32.3	28.0-40.0	4	21.4	16.8	8-29
P. richii					3	20.0	22.3	22.0-23.0	1	0.8	11.0		5	6.0	12.4	11-14

Appendix 6.7 (Contd.) a. Beach seine samples.

	BEACH SEINES															
	May 1976				August 1976				October 1976				January 1977			
		Biomass	Size			Biomass	Size			Biomass	Size			Biomass	Size	
Species	No.	(gr)	x̄	Range	No.	(gr)	x̄	Range	No.	(gr)	x̄	Range	No.	(gr)	x̄	Range
Telmessus cheiragonus					6	2.7	8.0	2.5-13.0	7	78.1	26.3	20.0-49.0	1	7.7	23	
Hermissenda crass.	29				20	--										
Melibe leonina	37	--			1	--							2	6.8		
Amphissa columbiana	2	0														
Clinocardium nuttalli					1	--										
Littorina sculata	1	0.1														
L. sitkana	1	0.1														
Margarites pupillus	32	3.8														
Nassarius mendicus	4	0.2			1	0.6										
Pollinices lewisi					1	--							1			
Dendraster excentricus	2	0.1														
Anthopleura elegant.					1	0.9										
Octopus sp.													1	--		
Total	541	99.4			58	76.1			31	167.3			147	160.7		
Site: Twin Rivers																
Crangon sp.	2	1.4	0													
C. alaskensis	2	3.8	10.0	10.0												
C. nigricauda	11	11.9	8.5	7.0-12.0	47	64.4	8.7	4.0-14.0					10	18.1	13.3	12-17
C. styliostris	7	10.2	10.3	8.5-12.0	2	1.4	7.5	5.0-10.0					3	6.6	14.7	13-18
Eualus pusiolus													4	2.4	7.3	5.0-8.0
Heptacarpus brev.	5	3.9	7.1	6.0-7.5	7	5.2	5.8	3.0-8.0								
Amphithoë lacertosa	1	0														
Anisogam. confervicolus					1	0										
Atylus tridens	2	0			15	0										

Appendix 6.7 (Contd.) a. Beach seine samples.

BEACH SEINES

	May 1976				August 1976				October 1976				January 1977			
		Biomass	Size			Biomass	Size			Biomass	Size			Biomass	Size	
Species	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range	No.	(gr)	$\bar{x}$	Range
Argeia pugettensis					1	0										
Idotea fewkesi					1	0.3										
P. wosnesenskii					1	0.1										
Rocinela belliceps													1	0.4	22	
Cancer magister					86	--	10.9	5.1-17.8	40	0	12.4	7.6-17.8	4	--	15.56	7.62-15.24
Acanthomysis sculpta					9	0.1										
Total	30	31.2			170	71.5			40	0			22	27.5		
Site: Kydaka Pt.																
Crangon stylirostris	28	65.0			20	34.4	10.0	5.5-15.0					36	64.7	14.1	10-20
Argeia pugettensis	5	0											2	--		
Gnorimosphaeroma oreg.					1	0.1			SITE NOT SAMPLED							
P. wosnesenskii					2	0.4										
Pentidotea montereyensis													1	0.2	25	
Cancer magister	2	--	5.3	5.0-5.5									1	2.3	23	
Medusa sp.													2	3.9		
Unident. mysid													7	0.2	14.1	
Total	35	65.0			23	34.9							49	71.3		

Appendix 6.7 Macroinvertebrate abundance and biomass raw data, 1976:
b. Townet samples (biomass in g, size in mm).

TOWNET SAMPLES

Species	May 1976				August 1976				December 1976				October 1976			
		Biomass	Size			Biomass	Size			Biomass	Size			Biomass	Size	
	No.	(gr)	x̄	Range	No.	(gr)	x̄	Range	No.	(gr)	x̄	Range	No.	(gr)	x̄	Range
Site: Jamestown																
Callianassa californiensis					1	4.7	67	--								
Crangon sp.	1	0.1	5.5	--												
C. alaskensis	85	16.8	5.4	2.5-7.0					52	5.7	6.5	4-13				
C. franciscorum					13	3.6	6.8	5-12					49	18.9	7.0	3-13
C. stylirostris	1	0	5.3	--												
Eualus avinus													2	0.8		
E. fabricii					35	6.0	10.7	7-18	7	2.0	--	--	60	21.9	14.6	8-20
E. townsendi													7	0.9	10.9	9-15
Heptacarpus stylus																
H. taylori									18	2.3	--	--				
Pandalus stenolepis													7	7.3	24.7	20-30
Sclerocrangon alata									2	0.1	18	16-20				
Amphithoë humeralis					7	0.9	22.1	19-30					4	0.7	23.5	20-27
Anonyx laticoxae					3	0.3	17.3	17-18	94	17.3	22.4	19-25	4	0.8	19	18-20
Atylus tridens	79	5.1	--	--	17	1.0	17.7	11-22	6	6.2	20.2	18-22	40	3.7	16.2	12-23
Gnorimosphaeroma sp.													3	0.2	8.7	7-10
G. oregonensis					1	0	9	--								
Pentidotea resecata	1	0.1	--	--									1	0.7	37	--
Rocinela belliceps					1	0.1	11	--								
Synidotea bicuspida	94	5.9	--	--												
Glycera capitata									1	2.8	115	--				
Fabia subquadrata	3	0.1	3.7	3.0-4.0												
Crab megalops					3	0.1	--	--								

Appendix 6.7 (Contd.) b. Townet samples.

	TOWNET SAMPLES															
	May 1976				August 1976				December 1976				October 1976			
		Biomass	Size			Biomass	Size			Biomass	Size			Biomass	Size	
Species	No.	(gr)	x̄	Range	No.	(gr)	x̄	Range	No.	(gr)	x̄	Range	No.	(gr)	x̄	Range
Crab zoea																
Aequorea aequorea					2	0.5	24	23-25	1	2.7	55	--	4	3.0	48.5	38-55
Hydromedusa sp.	200	0.3	--	--												
Acanthomysis macropsis																
A. sculpta													6	0.1	11.8	10-13
A. sculpta var. nuda													1	0		
Archaeomysis grebnitzkii													3	0.2	17.7	17-18
Proneomysis wailesi													6	0.4	15.5	13-21
Totals	464	28.4			83	17.2			181	39.1			197	59.6		
Site: Dungeness Spit																
Crangon alaskensis	7	2.7	6.8	5.0-8.0					50	16.0	7.8	7-11				
C. franciscorum					13	1.5	5.6	3-8								
C. nigricauda									1	0.2	7	--				
Eualus fabricii					12	2.1	10.2	6-21	71	18.1	13.7	9-19				
Heptacarpus brevirostris									3	0.5	5	4-7				
Pandalus danae									1	0.9	22					
P. stenolepis					1	0.5	18	--								
Sclerocrangon alata					1	0.3	6	--								
Upogebia pugettensis	1	0.1	--	--												
Amphilisca agassizi					1	0	--	--								
Amphithoë humeralis					2	0	7	4-10	3	0.4	20	19-21				
Anonyx laticoxae					1	0.1	15	--	1	0.2	21	--				
Atylus tridens	24	1.1	--	--	184	15.6	16.4	4-21	39	4.9	18.6	11-23				

Appendix 6.7 (Contd.) b. Townet samples.

TOWNET SAMPLES

Species	May 1976				August 1976				December 1976				October 1976			
	No.	Biomass (gr)	Size $\bar{x}$	Size Range	No.	Biomass (gr)	Size $\bar{x}$	Size Range	No.	Biomass (gr)	Size $\bar{x}$	Size Range	No.	Biomass (gr)	Size $\bar{x}$	Size Range
Pontogenia ivanovi									1	0.1	17	--	SITE NOT SAMPLED			
P. rostrata	6	0.1	--	--												
Westwoodilla caecula									3	0.1	13	--				
Gnorimosphaeroma oregonensis	2	0	--	--					1	0	7	--				
Idotea rufescens					1	0.1	15	--								
Pentidotea resecata									1	0.1	22	--				
P. wosnesenski					2	0.2	13	8-18								
Rocinela belliceps					1	0.1	14	--								
Synidotea bicuspida	1	0	--	--					1	0	12	--				
Tecticeps pugettensis					59	6.5	11.9	8-18								
Tomopteris septentrionalis	6	0	--	--												
Fabia subquadrata	4	0.1	3.3	2.5-4.0												
Crab zoea					5	0.1	--	--	1	0	--	--				
Hydromedusae	31	--														
Beroë sp.									2	0.4	21	19-23				
Thysanoessa inermis																
Acanthomysis macropsis					5	18.0	5.8	15-22	6	0.1	16.2	13-18				
A. nephrophthalma	2	0	--						1	0	17	--				
A. sculpta					14	0.4	14.1	13-15	124	2.0	9.5	9-12				
A. sculpta var. nuda									1	0	17	--				
Archaeomysis grebnitzkii	34	2.3							121	6.8	18	13-20				
Mysis oculata					22	1.0	15.5	13-22								
Neomysis sp.									1	0	--	--				
Neomysis rayii					1	0.1	24	--								
Pronoeomysis wailesi									4	0.1	15.5	13-18				
Mysid, unidentified									5	0	12.4	12-13				
Total	118	6.4			325	46.6			442	50.9						

Appendix 6.7 (Contd.) b. Townet samples.

	May				August				December			
			Size				Size				Size	
Species	No.	Biomass (g)	$\bar{x}$	Range	No.	Biomass (g)	$\bar{x}$	Range	No.	Biomass (g)	$\bar{x}$	Range
Pugettia gracilis					2	12.5	19.5	11-28				
P. producta					1	14.8	31	--				
Hydromedusa	71	--	--	--								
Euphausia pacifica	6	0.1	--	--								
Thysanoessa longipes	16	1.3	--	--								
T. raschii	22	0.34										
T. spinifera	7	0	--	--								
Acanthomysis macropsis	3	0	--	--								
A. nephrophthalma	1	0	--	--								
Archaeomysis grebnitzkii	1	0	--	--								
Neomysis sp.					4	0.2	20.8	15-24				
N. kadiakensis	2	0	--	--								
N. rayii	3	0	--	--								
Total	139	1.8			12	29.7						
Site: Beckett Point												
Crangon alaskensis	11	0.9	4.3	2.0-5.0					NOT SAMPLED			
Pandalus danae					4	5.3	21.0	18-25				
Atylus tridens	3	0	--	--								
Synidotea bicuspida	5	0	--	--								
Crab megalops	1	0	--	--								
Crab zoea	26	0	--	--								
Hydromedusae	112	0	--	--								
Total	158	0.9			4	5.3						

Table title: TOWNET SAMPLES 1976

Appendix 6.7 (Contd.) b. Townet samples.

	TOWNET SAMPLES 1976											
	May				August				December			
		Biomass	Size			Biomass	Size			Biomass	Size	
Species	No.	(g)	$\bar{x}$	Range	No.	(g)	$\bar{x}$	Range	No.	(g)	$\bar{x}$	Range
Site: Kydaka												
Crangon alaskensis									9	1.9	6.3	2-18
Heptacarpus tenuissimus									6	0.4	8.3	5-11
Anonyx laticoxae									1	0.2	20	--
Atylus tridens									7	0.5	19.7	12-21
Rocinela belliceps	NOT SAMPLED				NOT SAMPLED				1	0.2	16	--
Synidotea bicuspida									1	0	7	--
Polychaeta									1	0	--	--
Acanthomysis macropsis									60	2.3	17.5	12-21
Archaeomysis grebnitzkii									9	0.2	14.6	11-16
Neomysis kadiakensis									10	0.3	17.1	14-22
Neomysis rayii									10	0.4	19.3	14-22
Octopus dofleini									1	0.7	12	--
Total									116	7.1		
Site: Pillar Point												
Crangon alaskensis	1	0.1	7.0	--								
Heptacarpus tenuissimus					2	1.1	16.5	12-21				
Amphithoë sp.					1	0.5	34					
Atylus tridens	2	0	--	--								
Gam. amphipod sp.					1	0	4	--				
Pentidotea resecata					1	0.6	39	--				
Synidotea bicuspida	1	0	--	--								
Platynereis bicanaliculata	1	0	--	--								
Tomopteris septentrionalis	1	0	--	--					NOT SAMPLED			
Fabia subquadrata	1	0	1.5	--								

Appendix 6.7 (Contd.) b. Townet samples.

TOWNET SAMPLES 1976

Species	May				August				December			
	No.	Biomass (g)	Size $\bar{x}$	Size Range	No.	Biomass (g)	Size $\bar{x}$	Size Range	No.	Biomass (g)	Size $\bar{x}$	Size Range
Site: Morse Creek												
Crangon alaskensis	3	0	6.9	6.5-7.0					80	24.4	10.2	2-14
C. franciscorum					3	0.5	5.3	3-8				
Eualus fabricii												
Heptacarpus kincaidi					19	1.4	8.5	6-10	1	0.5	8	--
H. stylus	40	6.6	5.10	4-8								
H. tenuissimus									13	1.9	5.7	4-8
Pandalus stenolepis					2	1.8	24	--				
Anonyx laticoxae									6	1.2	22.3	20-24
Atylus tridens	6	0	--	--	3	0.2	16.3	16-17	23	2.3	19.2	15-23
Corophium brevis									1	0	15	--
Pontogenia rostrata	1	0	--	--								
Westwoodilla caecula									7	0.2	12	11-13
Gnorimosphaeroma oregonensis	4	0.1	--	--								
Pentidotea resecata	3	0.1	--	--								
Rocinela belliceps	1	0	--	--					1	0.1	15	--
Euphausiid (unident.)									1	0.1	18	--
Acanthomysis macropsis									4	0	14.5	12-17
A. nephrophthalma	1	0	--	--								
A. sculpta	6	0	--	--								
Archaeomysis grebnitzkii	159	6.4	--	--					317	16.6		
Neomysis rayii	3	0	--	--					214	5.8		
Beroë sp.									2	0.5	25	20-30
Total	227	13.2			27	3.9			670	53.6		

Appendix 6.7 (Contd.) b. Townet samples.

TOWNET SAMPLES 1976

	May				August				December			
		Biomass	Size			Biomass	Size			Biomass	Size	
Species	No.	(g)	$\bar{x}$	Range	No.	(g)	$\bar{x}$	Range	No.	(g)	$\bar{x}$	Range
Site: Twin Rivers												
Crangon alaskensis									5	1.3	6.6	2-11
C. franciscorum					2	0.3	5.5	4-7				
Eualus fabricii									237	41.0	12.8	10-19
E. suckleyi												
Heptacarpus tenuissimus									39	8.7	6.2	5-11
Pandalus stenolepis												
Atylus collingi									1	0	11	--
A. tridens	13	0.2			3	0.2	14.1	12-18	4	0.2	17.3	10-20
Gnorimosphaeroma oregonensis					3	0.1	8	--	1	0	7	--
Pentidotea resecata					2	0.3	18.5	12-25	6	0.8	19	13-29
Rocinela belliceps					1	0.2	18	--				
Polychaeta sp.									2	0.2	--	--
Crab zoea					1	0	--	--				
Euphausid sp.									2	0.2	21.5	19-24
Acanthomysis davisi	7	0.1										
A. macropsis	40	1.8							52	1.4	15.8	10-22
A. sculpta									8	0.1	11.1	10-12
Archaeomysis grebnitzkii									4	0.2	22	14-30
Boreomysis microps									3	0.1	19.3	18-21
Mysis oculata									2	0.1	20.5	20-21
Neomysis kadiakensis	19	0.1										
N. mercedis									4	0.2	18.3	15-20
N. rayii	2555	91.9			30	4.8	22.4	20-25	1856	61.6		
Proneomysis wailesi					57	3.4	18.9	11-25				
Diastylus sp.									3	0	6.3	5-9
Total	2634	94.1			99	9.3			2229	116.1		

Appendix 6.7 Macroinvertebrate abundance and biomass raw data (biomass in g):
c. Beach seine and townet samples, 1977-1978.

Site: Kydaka	May 1977				August 1977				October 1977				Dec. 1977 - Jan. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Cyanea					1	-[b]										
Pleurobranchia spp.					+	+										
Calliostoma ligatum			1	.04												
Haminoea virescens											1	.07				
Nudibranch spp.					1	.56										
Pollinices lewisi									1	b						
Lepidasthenia interrupta			3	.28												
Nereid spp.															2	.08
Acanthomysis macropsis			3	.03												
A. sculpta			1	.01												
Archaeomysis grebnitzkii											6	.21				
Neomysis rayii			3	.10							4	.08			856	36.66
Gnorimosphaeroma oregonensis											1	.01				
Pentidotea resecata			2	.95							2	.16				
Rocinela belliceps							2	.28								
Amphithoe humeralis							3	.08			17	3.11				
Anonyx laticoxae					14	1.09					2	.16			11	.28
Atylus tridens							2	.04			12	.60				
Gammaridae spp.			6	.07					3	1.16						
Cancer magister	1	.60			33[a]	55.99			39[c]	174.28						
Crangon alaskensis					9	3.45	5	1.28	116	177.08	2	.03			1	.05
C. nigricauda					1	.30										
C. stylirostris	7	10.35			5	6.81										
Eualus fabricii							97	21.09								
Heptacarpus brevirostris					1	.32										
H. flexus											15	3.34			2	.23
Hippolytidae			+	+												
Megalops			2	.06			11	.27								
Pandalidae			2	.03												
Pandalus danae											1	1.42				
P. goniurus											1	1.78				
Unidentified bryozoans			1	.27												
Total	8	10.95	24	1.78	65	68.52	120	23.04	159	352.52	64	10.97	-	-	872	37.38

[a] Immature *C. magister* filled the wings, too numerous to count, size approximately 20-25 mm.
[b] *Cyanea* bell measured 200 mm; not weighed, measured in field (*Pollinices*).
[c] 62 *C. magister* were measured but only 39 weighed; 23 were measured in field and released.
+Present, but not enumerated or weighed.

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

Site: West Beach	May 1977				August 1977				October 1977				Dec. 1977 - Feb. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Jellyfish			+	+												
Pleurobranchia sp.							2	.56								
Haminoea virescens			1	.24											2	.45
Littorina spp.	107	.04														
Notoacmaea persona					1	.15										
Pteropod											1	.15				
Thais lamellosa					3	34.07										
Clinocardium nuttalli					1	5.85										
Gonatus fabricii							1	1.16								
Loligo opalescens											6	18.89			1	3.72
Polychaeta	1	-														
Tomopteris septentrionalis															1	.02
Acanthomysis columbiae							1	.06								
A. macropsis			8	.44												
A. pseudomacropsis					1	.02										
A. sculpta	10	.19			35	.66										
Archaeomysis grebnitzkii	1	.06			1	.03									43	1.78
A. maculata			102	2.64												
Mysid	33	.18														
Neomysis awatschensis											7	.43				
N. kadiakensis			120	5.08												
N. rayii			32	1.00							24	1.31			70	2.92
Cumacean			+	+												
Gnorimosphaeroma oregonensis	1	.15													2	.06
Idotea sp.	3	.01														
Idotea fewkesi	1	.02														
Pentidotea montereyensis					1	.50										
P. resecata			1	.13												
Rocinela bellicepa							1	.46			3	1.38			3	.78

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

Site: West Beach	May 1977				August 1977				October 1977				Dec. 1977 - Feb. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Synidotea bicuspida			1	.04											2	.04
Amphithoe spp.	+	+														
Atylus tridens			280	11.76	12	.09	13	.90			15	1.08			117	7.33
Calliopius spp.					1	.01										
Gammaridae	1230	7.19	8	.12							4	.08			23	.69
Westwoodilla caecula	+	+													10	.32
Euphausia pacifica															25	.73
Thysanoessa raschii			20	1.35												
T. spinifera			104	8.60			1	.08			1	.07			15	.96
Cancer gracilis					1	10.50										
C. magister	10	13.37			1	.68							3	46.75		
Crangon alaskensis	16	8.92	7	3.08	23	10.29							16	13.15	68	7.85
Eualus avinus	10	6.26														
E. fabricii	1	.61														
Heptacarpus brevirostris															16	.74
H. flexus											14	-				
H. tenuissimus	1	.21														
Megalops			+	+	6	.14										
Pagurus hirsutiusculus													1	.61		
P. granosimanus					1	1.54										
Pandalus danae											1	-				
P. goniurus											1	-			1	1.86
Pugettia richii					2	4.10										
Sclerocrangon alata															2	.08
Zoea			+	+												
Dendraster excentricus	1	53.55														
Chaetognath			+	+												
Total	1402	90.76	684	34.48	90	68.57	19	3.22			77	23.39	20	60.51	401	30.54

+Present but not quantified.

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

Site: Alexander Beach	May 1977				August 1977				October 1977				Dec. 1977 - Feb. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Jellyfish			+	+												
Pleurobranchia sp.							100	23.73								
Ctenophora											2	-				
Haminoea virescens															1	.42
Littorina sitkana			7	.88												
Thais lamillosa					4	63.11										
Gonatus fabricii			1	29.61												
Loligo opalescens							1	9.79								
Octopus spp.															1	.29
Flabelligera infundibularis			1	.32												
Nereis vexillosa													1	2.68		
Nereid															1	.26
Polychaeta									1	.26						
Acanthomysis sculpta	1	-														
Archaeomysis grebnitzkii											3	.07			12	.31
Neomysis rayii			2	.06			1	.10			3	.12			9	.35
Cumaceans											1	.02				
Pentidotea montereyensis					5	2.24									2	.08
P. resecata															1	.31
Rocinela bellicepe			3	1.05			3	.75					1	.08	1	.03
R. propodialis							2	.66								
Synidotea bicuspida			5	.16												
Westwoodilla caecula															3	.06
Amphithoe lacertosa					5	.40										
Anonyx laticoxae											1	.04			155	14.53
Atylus tridens			1560	81.80			11	.95	17	1.22	56	3.80	1	.08	41	9.13
Gammaridae	1	.02	25	.31							4	.04			2	.32
Hyperiidae											1	.02			1	.04
Euphausid											2	.02				
Euphausia pacifica															41	1.11
Thysanoessa spinifera															3	.15

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

Site: Alexander Beach	May 1977				August 1977				October 1977				Dec. 1977 - Feb. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Cancer gracilis					2	9.93										
C. magister					6	11.70							2	19.14		
Crangon alaskensis	3	1.16	21	15.33	70	25.56	3	.79	30	12.41	1	.23	28	14.88	7	1.11
Eualus avinus					5	1.10										
Heptacarpus brevirostris													46	19.24	2	.17
H. flexus											2	.96				
H. kincaidi											1	.52				
H. stimpsoni											1	.11				
H. taylori									5	2.00			2	2.61		
Pagurus hirsutiusculus	3	27.70											2	1.75		
P. granosimanus	2	2.35			1	.31							4	10.77		
Pandalus danae					2	.94										
P. goniurus							8	3.84								
P. montagui tridens			2	1.98			1	.46	4	18.33	11	18.58				
Pugettia gracilis									1	.47						
P. richii					3	.18										
Spirontocaris spp.							1	.05								
Zoea			+	+												
Chaetognaths			+	+												
Total	10	31.23	1627	131.50	103	115.47	130	41.12	58	34.69	89	24.53	87	71.23	283	28.67

+Present but not enumerated

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

Site: Beckett Point	May 1977				August 1977				October 1977				Dec. 1977 - Jan. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Jellyfish			50	3.18												
Pleurobranchia sp.	15	6.89	50	2.04												
Aglaja diomedia	2	.56														
Collisella pelta	1	.06														
Haminoea spp.	3	.29														
Hermissenda crassicornis	2	2.91														
Littorina planaxis	10	.18														
L. scutulata	1	.05														
Melibe leonina	1	19.67														
Nudibranch									1	2.16						
Pollinices lewisi													4	-		
Mytilus edulis	1	.02														
Tresus capax													2	92.61		
Nereid	2	.11														
Phyllodocid	1	.02														
Polychaeta	2	.03														
Leech	1	.02														
Acanthomysis macropsis			5	.06												
A. nephrophthalma			1	.02												
Neomysis rayii											9440	768.40				
Pentidotea resecata	8	3.75							3	1.26			3	.46		
Rocinela bellicepa							1	.36								
Synidotea angulata			1	.03												
Amphithoe lacertosa					2	.13										
Atylus tridens			10	.64												
Gammaridae			7	.10												
Thysanoessa raschii			20	.44												
Thysanoessa spinifera			5	.24												
Cancer gracilis	10	9.75			3	1.79			2	136.60						
Cancer magister					8	20.19			4	-			2	43.13		

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

Site: Beckett Point	May 1977				August 1977				October 1977				Dec. 1977 - Jan. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Cancer oregonensis					3	-										
C. productus	1	-			9(3)*	78.73			2	140.20						
Crangon alaskensis	14	23.95			1	1.16			13	12.75			42	40.33		
C. nigricauda	3	1.78														
Eualus spp.	14	6.98														
E. townsendi	1	.24														
Heptacarpus flexus											41	12.60	3	1.26		
H. kincaidi	9	.81							2	.31			1	.08		
H. stimpsoni					8	.87										
H. stylus													1	.22		
H. taylori									8	5.76			7	1.27		
Hippolyte clarki	150	11.98														
Hippolytidae			2	.01					+	+						
Lebbeus grandimanus	1	.01							1	.14						
Oregonia gracilis					9	.94										
Pagurus beringanus													3	97.20		
P. capillatus													1	.11		
P. hirsutiusculus	10	3.21			1	.21			1	1.44			14	6.96		
P. granosimanus	7	.98			2	1.80										
Pandalidae									+	+						
Pandalus danae					66	77.70			182	580.86	7	9.38	2	7.60		
P. montagui tridens											11	23.20				
P. platyceros									59	220.80	2	9.81				
Pugettia gracilis									4	8.10			1	1.02		
P. producta	4	18.45							1	3.50			8	22.68		
P. richii					3	.21										
Telmessus cheiragonus					55(52)*	135.12			25	306.00						
Total	274	112.70	151	6.77	110	318.85	1	.36	308	1419.88	9501	823.39	94	314.93		

*Telmessus: 55 caught but only 52 weighed = 135.12g. C. productus: 9 caught but only 3 weighed.
+Present but not enumerated.

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977–1978.

Site: Point Williams	May 1977				August 1977				October 1977				Dec. 1977 - Jan. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Aequorea aequorea											21	16.34				
Gonionemis vertens					3	2.15										
Nemertean			1	.40												
Littorina spp.	1	.02														
L. planaxis					1	.03										
Notoacmaea persona					2	.07										
N. scutum													2	.17		
Philine spp.											2	.60				
Pteropod															2	.79
Clinocardium nuttalli					1	65.88							1	-		
Gonatus fabricii			5	11.48												
Loligo opalescens							2	1.23								
Nereid									1	.28						
Nothria elegans			1	.11												
Acanthomysis davisi			1	.01												
A. macropsis			5	.06			2	.02								
A. nephrophthalma			1	.01												
A. pseudomacropsis															2	.10
Archaeomysis grebnitzkii			5	.19												
Mysis oculata			1	.03												
Neomysis rayii			1	.04			1	.03								
Cumaceans	+	+	+	+												
Pentidotea montereyensis					1	.19			1	.13			2	.20		
P. resecata	9	6.03	1	.14											4	.54
P. wosnesenskii					3	.80										
Rocinela belliceps			1	.07											1	.54
Synidotea angulata															3	.12
Amphithoe lacertosa					2	.05										
Anonyx laticoxae													1	.20	51	12.55
Atylus tridens	1	.11	52	3.05	6	.24	1	.05	1	.13	3	.41				
Gammaridae	4	.04	116	2.02	3	.02	3	.41	2	.13	5	.57	1	.04	1	.17

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

Site: Point Williams	May 1977				August 1977				October 1977				Dec. 1977 - Jan. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Euphausia pacifica															4	.17
Callianassa californiensis											1	2.05				
C. gigas			5	2.62												
Cancer magister					2	2.65			37	289.44			16	14.97		
C. productus	1	-			1	-			3	-			1	4.22		
Crangonidae			+	+												
Crangon alaskensis	1	.57	10	3.93	3	1.51			67	101.92	1	1.53	66	50.38	2	1.25
C. nigricauda	1	4.23														
Eualus avinus	27	16.36														
E. fabricii							1	.11								
E. pusiolus							1	.04								
Heptacarpus brevirostris									30	25.09			30	18.60		
H. flexus											82	45.62	2	.31		
H. kincaidi											3	1.71				
H. paludicola					1	.24										
H. pictus	2	.22														
H. taylori			1	.19	47	14.88					3	1.76				
Hippolyte clarki	10	1.14														
Hippolytidae			+	+			3	.58								
Oregonia gracilis	1	.44			4	1.01										
Pagurus capillatus													1	2.04		
P. hirsutiusculus	1	1.95			4	21.02			5	8.13			5	6.76		
Pagurus granosimanus	1	.14														
Pandalidae			+	+												
Pandalus danae					64	58.80			2	6.40	37	72.27				
P. montagui tridens							1	1.20			25	49.36				
Pugettia gracilis	23	26.77			14	17.37			1	2.53			7	3.88		
P. producta	1	23.73														
Telmessus cheiragonus	9	145.77			1	13.78			16(2)[a]	6.18			1	8.60		
Upogebia pugettensis					1	1.04										
Leptasterias hexactus													1	2.01		
Chaetognaths			+	+												
Total	93	227.52	207	31.94	164	201.73	15	3.67	166	440.36	183	192.22	137	112.38	70	16.23

+Present but not quantified.

[a] 16 were measured but only 2 weighed. The two weighed 6.18.

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

Site: Dungeness Spit	May 1977				August 1977				October 1977				Dec. 1977 - Jan. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Aequorea aequorea					1	-					26	16.02				
Melibe leonina											1	1.79				
Tomopteris septentrionalis			1	.03												
Acanthomysis sculpta			60	.83												
Archaeomysis grebnitzkii			45	3.33			1	.06			202	9.90				
A. maculata			398	13.54												
Cumaceans			3	.03												
Gnorimosphaeroma oregonensis			10	.37			3	.24								
Pentidotea resecata							1	.25								
Rocinela belliceps													1	.31		
R. propodialis			2	.09												
Anonyx laticoxae			1	.04									15	5.31	4	.99
Atylus tridens			43	1.85			1	.09			32	6.18				
Gammaridae			12	.21							51	4.36				
Hyperiidae											1	.01				
Thysanoessa raschii			7	.17												
Cancer magister					42(29)	41.10*							33	156.87		
C. oregonensis					1	.04										
Crangon alaskensis	8	12.49	13	6.64	68	127.4	11	5.07			45	21.23	120	184.29	12	6.26
C. stylirostris	5	11.29			3	.75										
Heptacarpus brevirostris													3	2.77		
H. flexus											337	29.97			8	2.29
Hippolytidae			+	+												
Megalops			+	+			8	.13								
Pandalidae			+	+												
Pandalus danae	3	3.79			51	169.2					74	153.24				
P. goniurus											2	3.80				
Pinnotheres pugettensis							3	.18								
P. taylori			6	.17												
Pugettia gracilis											1	10.12				
Henricia leviuscula					4	16.97										
Total	16	39.06	541	27.30	170	355.46	28	6.02			772	256.62	172	349.55	24	9.54

*29/41 were weighed, therefore, 29 weighed 41.10g.
+Present but not quantified.

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

Site: Morse Creek	May 1977				August 1977				October 1977				Dec. 1977 - Jan. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Aurelia aurita					4	2.03										
Cyanea capillata			1	.62												
Jellyfish			✓	✓												
Beroe spp.			4	.28												
Haminoea virescens											1	.72				
Tomopteris septentrionalis			3	.08												
Acanthomysis davisi			4	.05												
Archaeomysis grebnitzkii			71	2.94							52	1.46				
A. maculata			17	.39												
Neomysis rayii											29	.50				
Gnorimosphaeroma oregonensis			1	.02					6	.88						
Pentidotea aculeata									4	2.65						
P. monteyensis													2	.37		
P. resecata			7	1.75							12	3.40				
P. wosnesenskii					1	.66										
Rocinela bellicеps							1	.05	2	.60	2	.73				
Tecticeps pugettensis			1	.03												
Amphithoe spp.											1	.02				
Anonyx laticoxae			1	.11					2	.27	43	5.97				
Atylus tridens			51	1.38	4	.22					27	.98				
Gammaridae			38	.47			1	.02	1	.27	12	1.10				
Cancer magister	4	16.50			5	*			37(31)	49.95+			51(45)	175.79+		
Crangon alaskensis					1	1.23			54	52.61	25	20.44	123	157.24		
C. nigricauda	4	2.25														
C. stylirostris	4	9.06			9	*										
Eualus fabricii							50	8.22								
Heptacarpus brevirostris									1	1.12						
H. flexus					2	.63			1	.57	110	28.70	4	2.53		
H. kincaidi											47	16.05				
H. stylus			1	.13												
H. tridens											14	2.99	1	.79		

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977–1978.

Site: Morse Creek	May 1977				August 1977				October 1977				Dec. 1977 - Jan. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Hippolytidae			1	.04												
Megalops			2	.10												
Pagurus spp.									1	.10						
Pandalidae			✓	✓												
Pandalus danae									4	31.98	11	28.46				
P. goniurus											4	3.96				
P. montagui tridens											22	39.08				
P. stenolepis			10	.20												
Pugettia gracilis					1	1.68			1	3.79						
Chaetognaths			14	1.46												
Total	16	27.81	227	10.05	27	4.71	52	8.29	114	144.19	412	139.50	181	336.72		

✓Present but not quantified.
*Measured in field and released, not weighed.
+31/37 were weighed. 31 weighed 49.95g.; 45/5' weighed, 45 weighed 175.79.

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

Site: Twin Rivers	May 1977				August 1977				October 1977				Dec. 1977 - Jan. 1978			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Jellyfish													2	137.20		
Ctenophore			+	+												
Acanthomysis davisi			1	.01												
A. nephrophthalma			7	.22												
A. pseudomacropsis							2	.04								
Neomysis rayii							7	.28			8640	521.44				
Cumaceans			+	+												
Idotea fewkesi													1	.19		
Pentidotea resecata							1	.04								
P. wosnesenskii					1	.35										
Rocinela propodialis			2	.03												
Atylus collingi					14	.25										
Atylus tridens	2	.21														
Caprella penantis							1	.03								
Gammaridae			9	.14					1	.41						
Thysanoessa spinifera			1	.09												
Cancer magister	4	*			52	*			21	*			2	*		
C. productus					1	*										
Crangon alaskensis	24	31.41			9	4.98			163	198.37			51	128.80		
C. nigricauda					107	69.39										
C. stylirostris	10	16.56			10	2.81										
Hemigrapsus oregonensis									1	5.46						
Heptacarpus brevirostris					1	.21			31	*						
H. flexus			3	1.04							36	15.24				
H. stylus			4	1.49												
H. taylori	1	.70	5	20.17									1	.87		
Pandalus danae									11	20.60						
Telmessus cheiragonus									3	29.02						
Zoea			+	+												
Chaetognaths			+	+												
Total	41	48.88	32	23.29	195	77.99	11	.39	231	253.86	8676	536.68	57	267.06		

*Measured and released, not weighed.

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

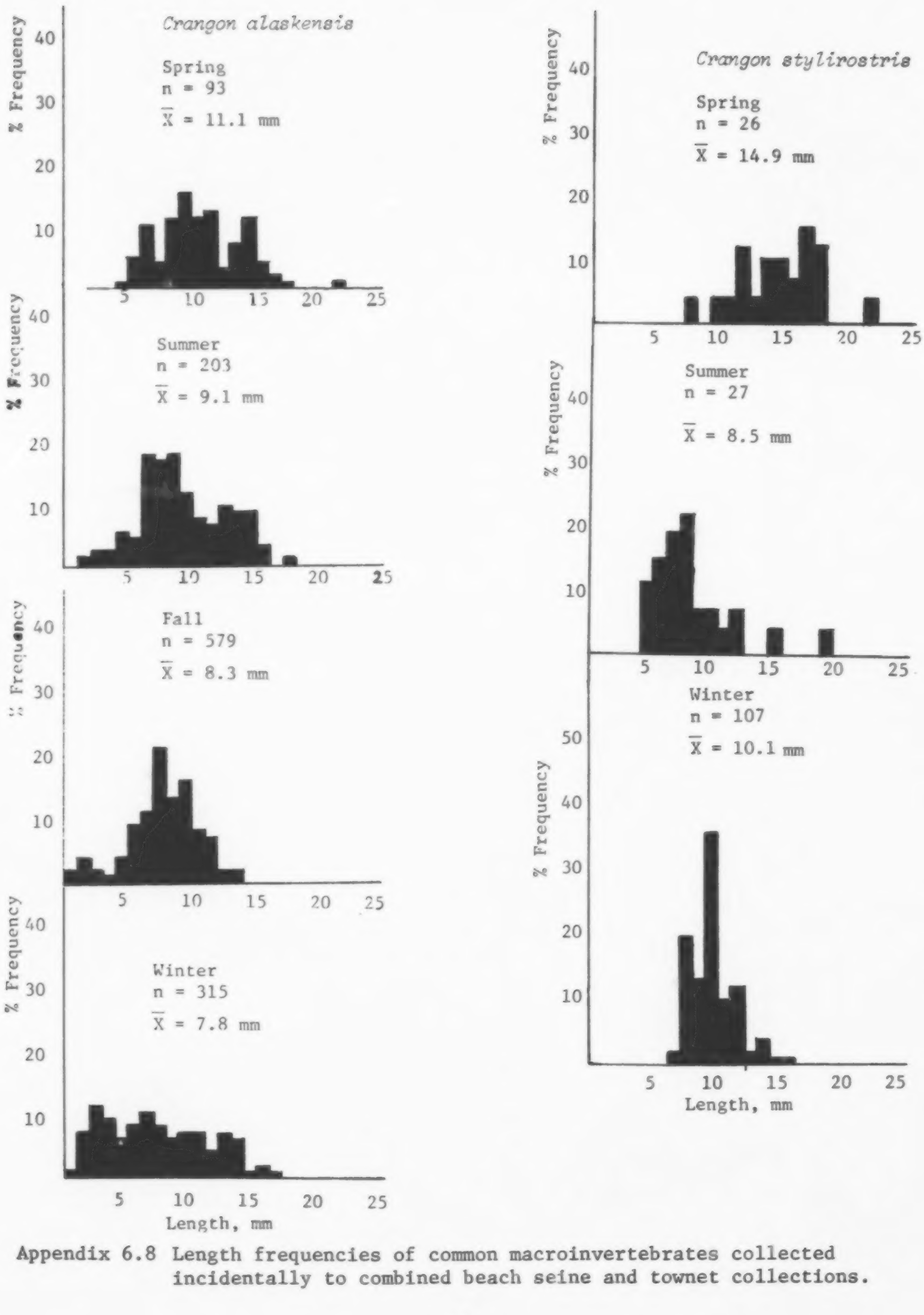
Site: Pillar Point	May 1977				August 1977				October 1977				Dec. 1977			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
Aequorea aequorea															5	21.50
Gonionemus vertens															191	29.95
Polyorchis penecillatus			1	.18												
Hydroids			1[a]	.55												
Beroe spp.			12	1.15												
Collisella instabilis			1	.22												
Unidentified snail			1	.04												
Clinocardium nuttalli			2	.07												
Gonatus fabricii							10	44.47								
Loligo opalescens											1	1.11				
Halosydna brevisetosa			13	1.94												
Tomopteris septentrionalis			3	.05												
Acanthomysis macropsis			13	.12												
Archaeomysis grebnitzkii											4	.07				
Neomysis rayii			53	1.63			1	.08			22	1.21			248	17.70
Cumaceans			+	+												
Dynamenella glabra			1	.01												
D. sheari											1	.06				
Pentidotea resecata			1	.08							3	.09			1	.03
P. wosnesenskii											1	.09				
Rocinela belliceps															2	.21
Synidotea angulata															1	.03
Westwoodilla caecula															6	.17
Amphithoe humeralis											9	.41				
Anonyx laticoxae															2	.04
Atylus tridens											10	.03				
Gammaridae			27	.46											12	5.25
Thysanoessa raschi			16	.43												
Thysanoessa spinifera			2	.22											6	.16
Crangon alaskensis			1	.26							17	.61			1	.04
Heptacarpus flexus			1	.45							5	.59			82	17.93

Appendix 6.7 (Contd.) c. Beach seine and townet samples, 1977-1978.

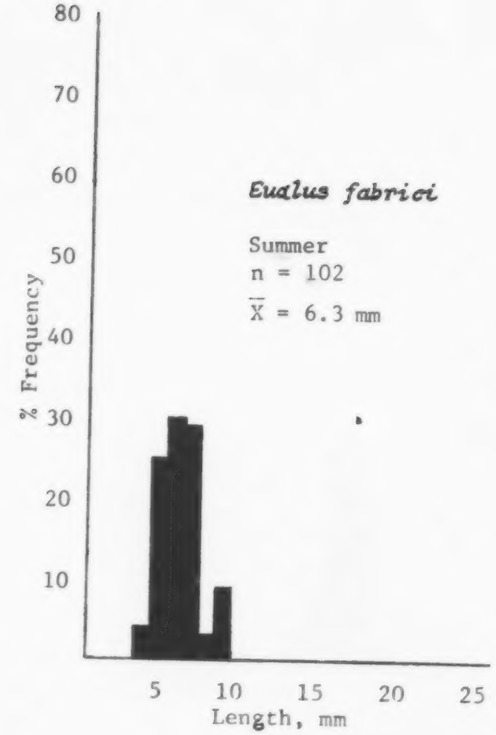
Site: Pillar Point	May 1977				August 1977				October 1977				Dec. 1977			
	Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet		Beach Seine		Townet	
Species	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass	No.	Biomass
H. kincaidi											4	1.67				
Hippolytidae			1	.02												
Lebbeus grandimanus															1	.28
Pandalidae			4	.07												
Pandalus montagui tridens											1	1.78				
Pinnotheres pugettensis			3	.11												
Sclerocrangon alata															1	.03
Ophiopholis aculeata			1	.84												
Chaetognaths			+	+												
Bryozoans			1[a]	2.88												
Total	-	-	144	11.78	-	-	11	44.82	-	-	78	7.72	-	-	559	85.32

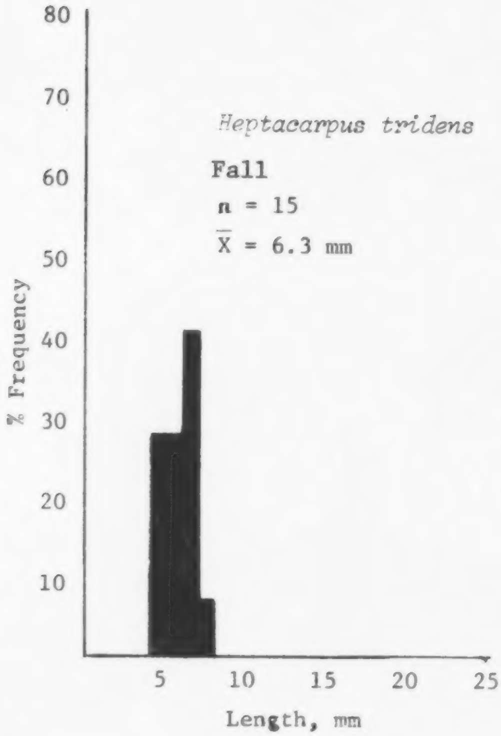
+Present but not quantified.

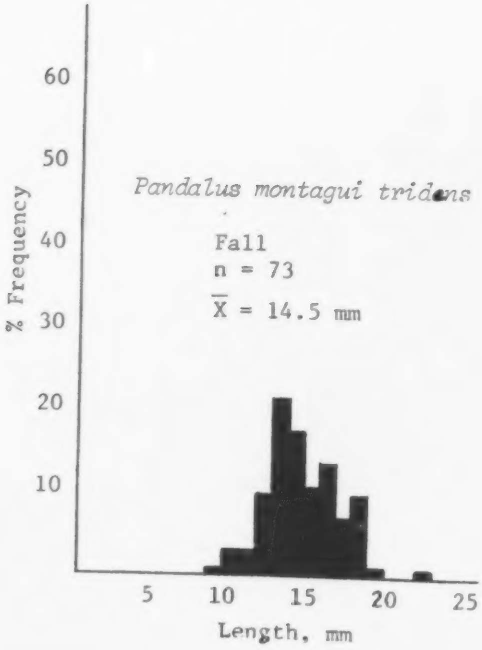
[a] A clump of organisms was counted as 1.

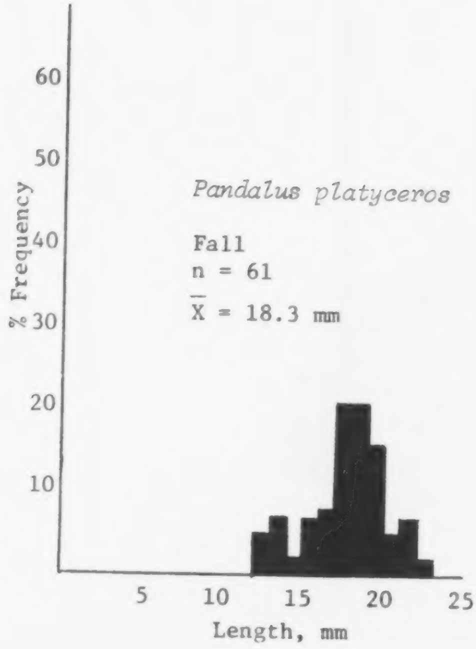


Appendix 6.8 Length frequencies of common macroinvertebrates collected incidentally to combined beach seine and townet collections.

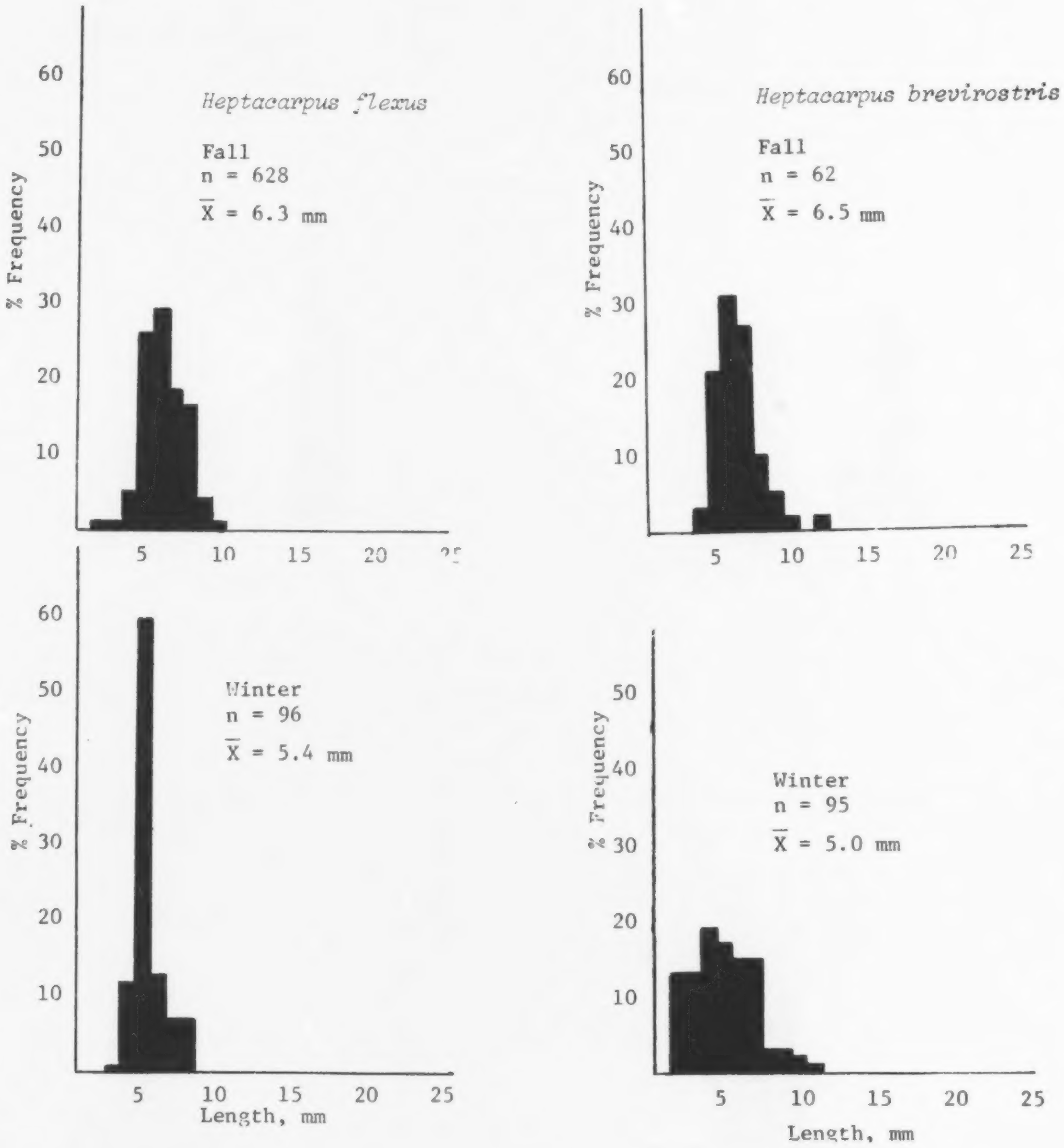




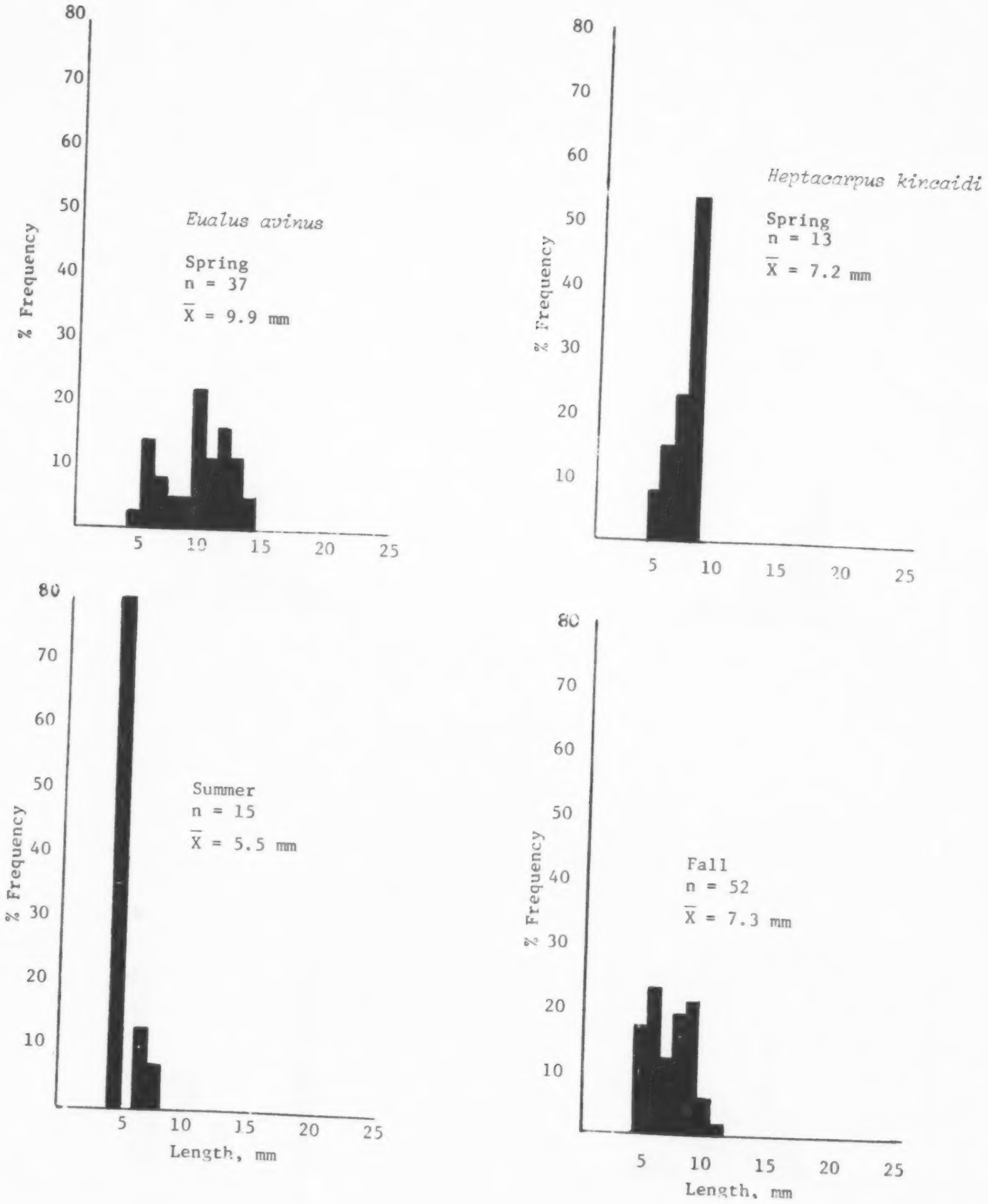




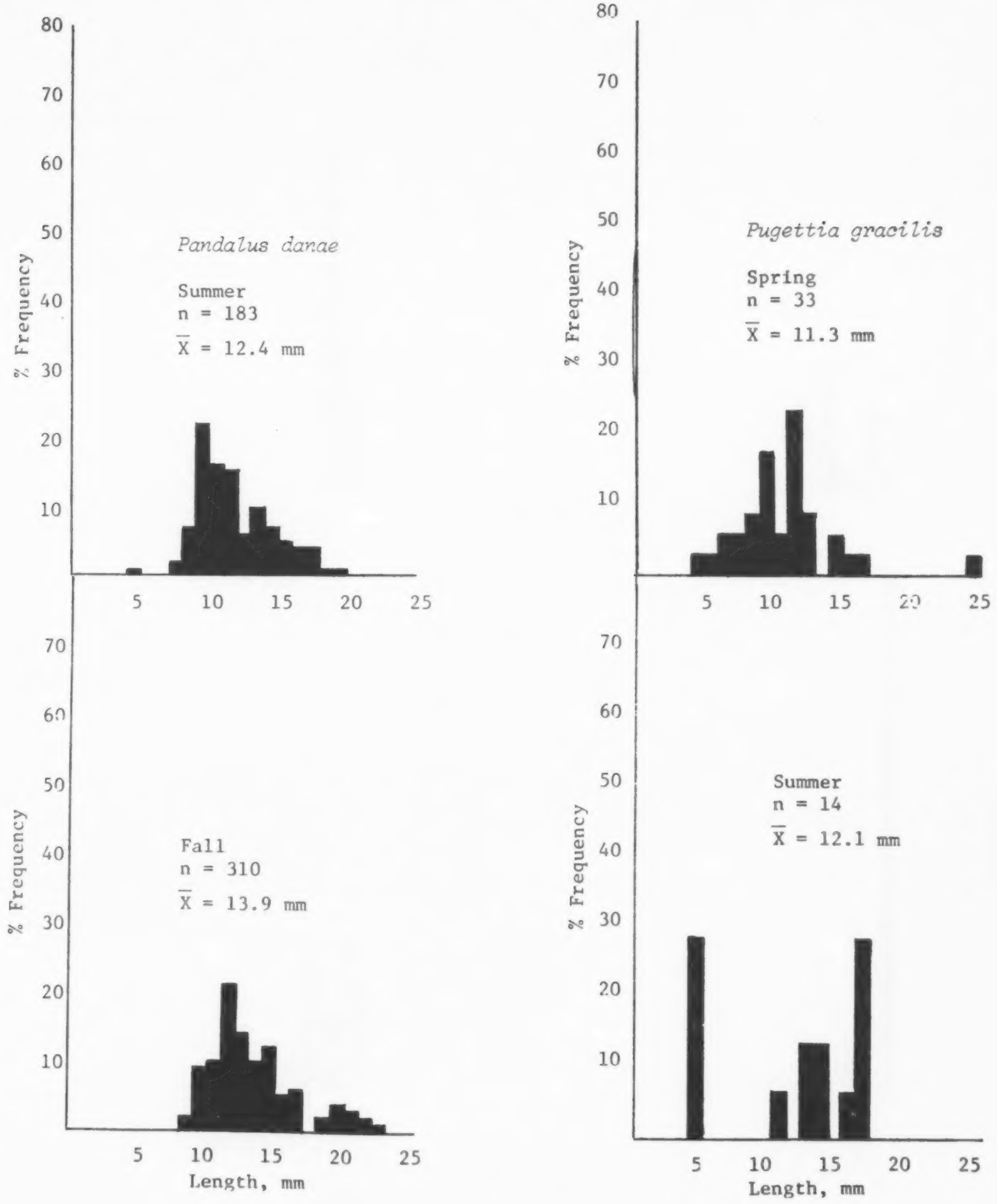
Appendix 6.8 (Contd.)



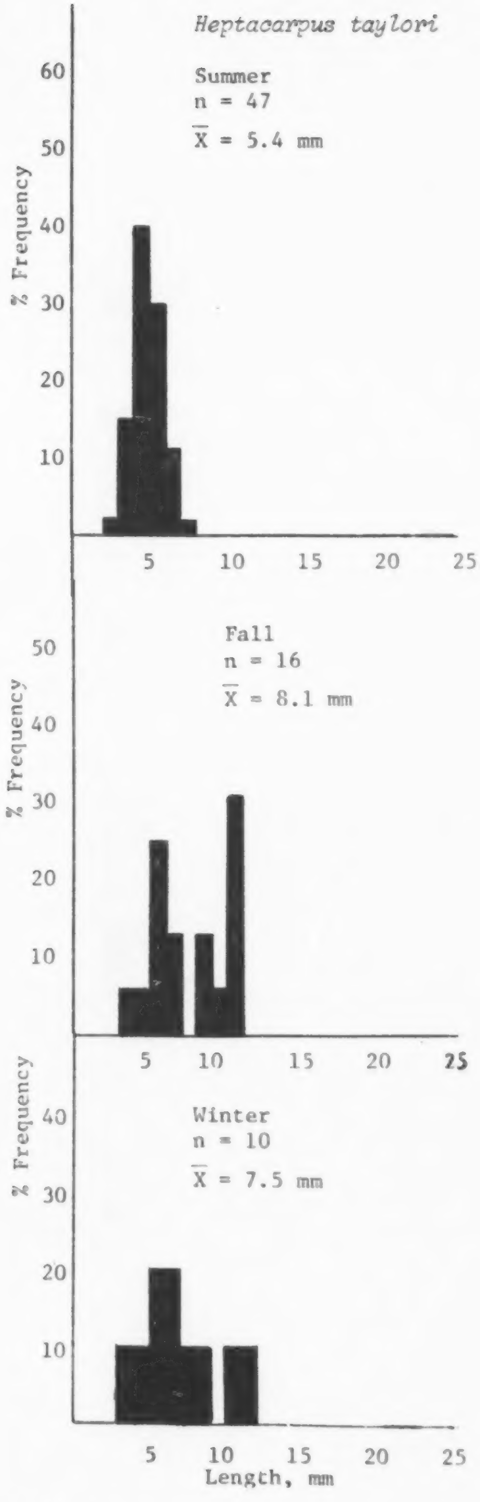
Appendix 6.8 (Contd.)

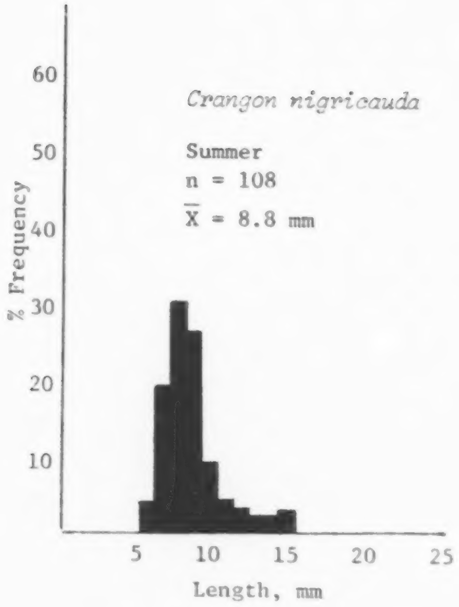


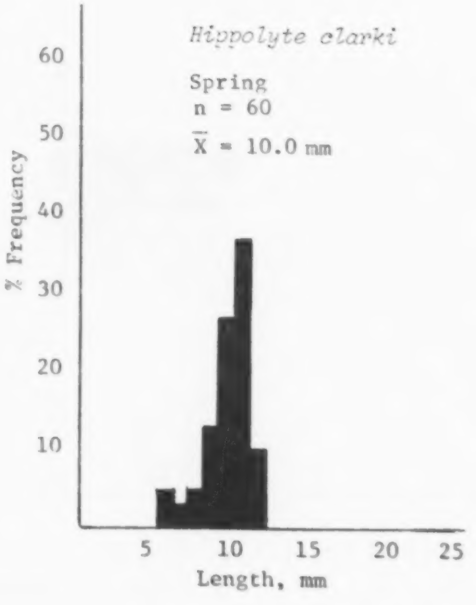
Appendix 6.8 (Contd.)



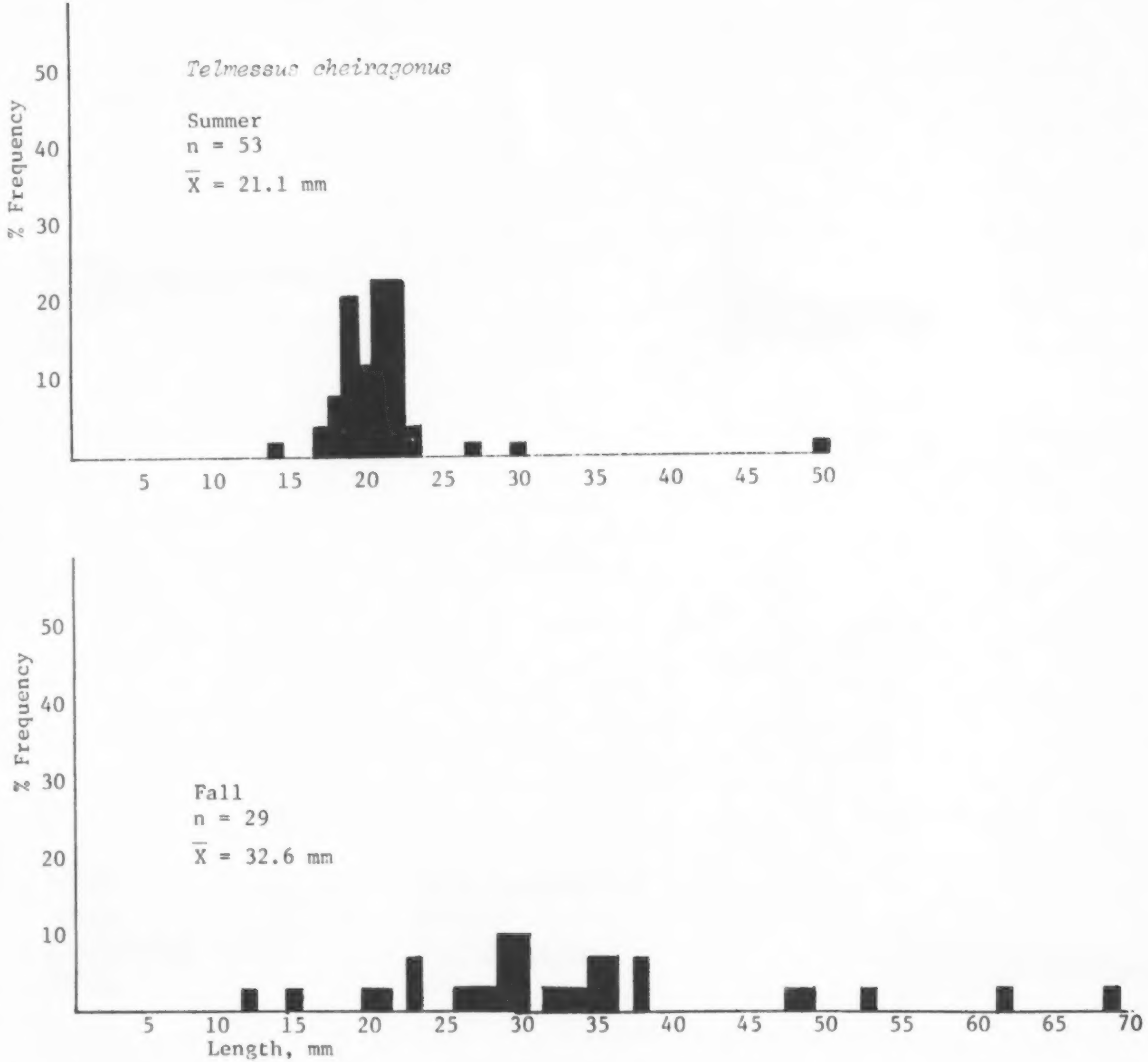
Appendix 6.8 (Contd.)



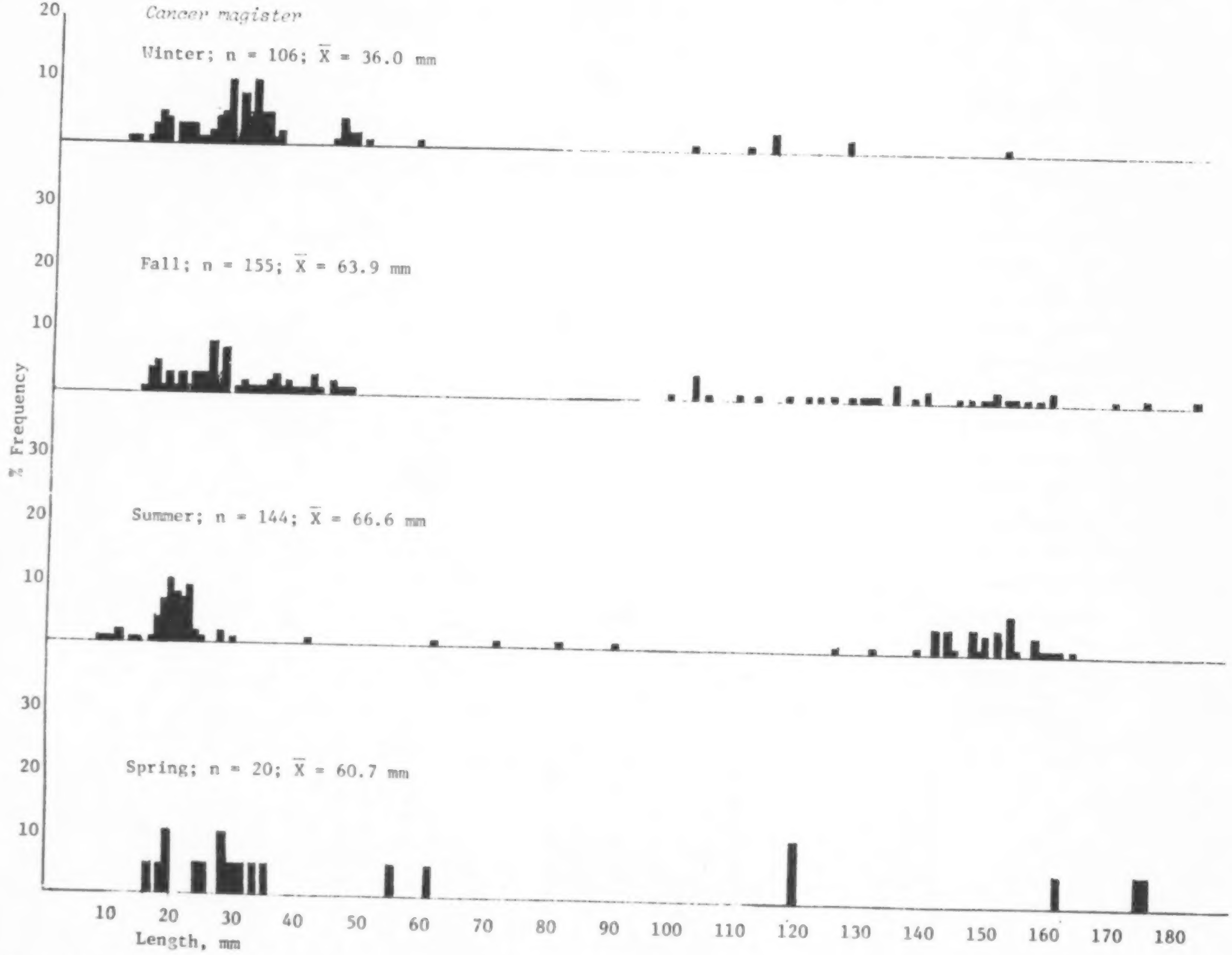




Appendix 6.8 (Contd.)



Appendix 6.8 (Contd.)



Appendix 6.8 (Contd.)

Appendix 6.9 Fish stomach samples: a. Sources and numbers of stomach samples analyzed from nearshore fish collections in the Strait of Juan de Fuca, 1978-1979.

	Beach seine						Townet							Intertidal						
Species	Kydaka Beach	Twin Rivers	Morse Creek	Dungeness Spit	Jamestown/Pt Williams	Beckett Point	Kydaka Beach	Pillar Point	Twin Rivers	Morse Creek	Dungeness Spit	Jamestown/Pt Williams	Beckett Point	Cape Alava	Neah Bay	Slip Point	Observatory Point	Twin Rivers	Morse Creek	North Beach
Spiny dogfish, Squalus acanthias												5								
Big skate, Raja binoculata				1																
Pacific herring juv., Clupea harengus pallasi			10	7			10	10	10	10		10								
Chum salmon juv., Oncorhynchus keta										1			12							
Coho salmon juv., O. kisutch													1							
Chinook salmon juv., O. tshawytscha	1					1	2	2					6							
Rainbow trout (steelhead) Salmo gairdneri			1																	
Night smelt, Spirinchus starksi								10												
Plainfin midshipman, Porichthys notatus						1														
Northern clingfish Gobiesox maeandricus			2											6	3	22	2	6	17	
Pacific tomcod juv., Microgadus pacificus			11	12		20														
Threespine stickleback, Gasterosteus aculeatus					1															
Tube-snout, Aulorhynchus flavidus			10	1		13														
Bay pipefish, Syngnathus griseolineatus						7														
Widow rockfish juv., Sebastes entomelas	10		9			15														
Kelp greenling juv., Hexagrammos decagrammus			2			3								1						
Rock greenling juv., H. lagocephalus														2						
Whitespotted greenling, H. stelleri						2														
Lingcod juv., Ophiodon elongatus	9																			
Padded sculpin, Artedius fenestralis	1	11			3	15											1			
Scalyhead sculpin, A. harringtoni																8				
Smoothhead sculpin, A. lateralis						2									12	30	9	5	6	2
Rosylip sculpin, Ascelichthys rhodorus		22													9	24	1	13	13	1
Silverspotted sculpin, Blepsias cirrhosus	1	14	13	3		1														
Sharpnose sculpin, Clinocottus acuticeps						3										7	2	13	5	
Calico sculpin, C. embryum																3	13		14	
Mosshead sculpin, C. globiceps														1	2	32	28		7	2
Buffalo sculpin, Enophrys bison		2			2	4										2	1			
Red Irish lord, juv. Hemilepidotus hemilepidotus																1				
Pacific staghorn sculpin Leptocottus armatus	11	4	8	16	15	11														
Great sculpin Myoxocephalus polyacanthocephalus						4														

Appendix 6.9 (Contd.) a. Sources and numbers of stomach samples analyzed...

Tidepool sculpin, *Oligocottus maculosus*					29	10									78	29	20	12	9
Saddleback sculpin, *O. rimensis*														2	13	12		1	
Fluffy sculpin, *O. snyderi*														17	56	6	15	2	
Manacled sculpin, *Synchirus gilli*			1																
Cabezon juv., *Scorpaenichthys marmoratus*					1														
Roughback sculpin, *Chitonotis pugetensis*						1													
Tadpole sculpin, *Psychrolutes paradoxus*					1														
Warty poacher, *Ocella verrucosa*		1		4															
Tubenose poacher, *Pallasina barbata*		11	10	2		6													
Ribbon snailfish, *Liparis cyclopus*																1			
Tidepool snailfish, *L. florae*					1								1		20	6		5	
Ribbon snailfish, *L. rutteri*		1														1			
Kelp perch, *Brachyistius frenatus*						10													
Shiner perch, *Cymatogaster aggregata*					1	15													
Striped seaperch juv., *Embiotoca lateralis*		8	2			3													
Pile perch, *Rhacochilus vacca*			1			20													
Redtail surfperch, *Amphisticus rhodoterus*		24																	
Pacific sandfish, *Trichodon trichodon*	1																		
High cockscomb, *Anoplarchus purpurescens*															43	12	16	6	
Ribbon prickleback, *Phytichthys chirus*													9		8	7		7	
Black prickleback, *Xiphister atropurpureus*													4		39	12			
Rock prickleback, *X. mucosus*															16	6	6	8	
Penpoint gunnel, *Apodichthys flavidus*		15	9			2								6	16	1	4	1	
Crescent gunnel, *Pholis laeta*		4	2		2	17								5	16	11	5	5	3
Saddleback gunnel, *P. ornata*		1				2													
Pacific sand lance juv., *Ammodytes hexapterus*	2		4																
Speckled sanddab, *Citharichthys stigmaeus*	20	9	12	11		3													
English sole juv., *Parophrys vetulus*	1		16	9	25	20													
Starry flounder, *Platichthys stellatus*	11	3	2		1	1													
C-O sole, *Pleuronichthys coenosus*						2													
Sand sole juv., *Psettichthys melanostictus*	18	17	18	23															
Total number of species, 62																			
Subtotal	86	147	143	89	82	214	12	22	10	11	15	19	24	56	434	161	103	109	7
Total	761						89						904						

*No identifiable organisms.

Appendix 6.9 (Contd.) b. Fish stomach contents statistics for nearshore fish collections in the Strait of Juan de Fuca, 1978-1979. See Methods and Materials for a description of condition and digestion factors. Statistics were generated from samples itemized in previous table.

	Total sample size n	Number (%) empty stomachs	Adjust. sample size n'	Condition factor X̄ 1 SD	Digestion factor X̄ 1 SD	Total contents weight X̄ 1 SD	Total contents abundance X̄ 1 SD	Diet diversity Shannon-Wiener Index Numbers	Diet diversity Shannon-Wiener Index Biomass
Spiny dogfish, Squalus acanthias	5	1(20.0)	4	2.0 0.0	4.5 0.6	0.70 0.86	39.5 53.7	1.39	2.23
Big Skate, Raja binoculata	1	0(0)	1	4.0	5.0	1.17	2.0	--	--
Pacific herring juv., Clupea harengus pallasi	67	4(6.0)	63	5.2 2.0	3.4 1.6	0.12 0.10	298.2 274.6	0.48	0.29
Chum salmon juv., Oncorhynchus keta	13	10(76.9)	3	4.3 1.5	2.7 2.1	0.37 0.30	140.7 241.0	0.15	0.15
Coho salmon juv., O. kisutch	1	0(0)	1	4.0	3.0	0.25	7.0	0.99	0.99
Chinook salmon juv., O. tshawytscha	12	1(8.3)	11	5.5 1.4	4.5 0.7	0.41 0.34	39.5 27.1	2.97	2.78
Rainbow trout (steelhead) Salmo gairdneri	1	0(0)	1	7.0	5.0	1.90	5.0	1.37	0.16
Night smelt, Spirinchus starksi	10	7(70.0)	3	3.3 1.5	2.7 2.1	0.02 0.02	1.7 2.1	1.92	1.61
Plainfin midshipman, Porichthys notatus	1	1(100.0)	0					--	--
Northern clingfish Gobiesox maeandricus	58	9(15.5)	49	4.2 1.4	3.7 1.1	0.10 0.17	27.1 142.1	1.81	3.71
Pacific tomcod juv., Microgadus pacificus	43	0(0)	43	5.3 1.7	4.4 1.0	0.22 0.53	14.3 19.1	3.12	2.27
Threespine stickleback, Gasterosteus aculeatus	1	1(100.0)	0						
Tube-snout, Aulorhynchus flavidus	24	6(25.0)	18	4.1±2.0	4.4±1.2	0.02±0.02	6.9±7.3	1.68	0.32
Bay pipefish, Syngnathus griseolineatus	7	6(85.7)	1	4.0	4.0	0.02	2.0	0.00	0.00
Widow rockfish juv., Sebastes entomelas	34	0(0)	34	5.3±1.7	4.6±0.6	0.11±0.10	70.6±149.7	0.57	1.68
Kelp greenling juv., Hexagrammos decagrammus	6	0(0)	6	4.8±1.7	3.7±1.5	0.35±0.26	11.3±7.0	3.11	2.62
Rock greenling juv., H. lagocephalus	2	0(0)	2	6.0±1.4	2.0±0.0	0.12±0.10	1.0±0.0	1.00	0.44
Whitespotted greenling, H. stelleri	2	1(50.0)	1	5.0	3.0	9.14	10.0	0.00	0.00
Lingcod juv., Ophiodon elongatus	9	3(33.3)	6	3.7±1.0	3.5±0.8	0.23±0.16	1.2±0.4	2.24	2.03
Padded sculpin, Artedius fenestralis	31	6(19.4)	25	5.2±1.4	4.0±1.4	0.15±0.21	3.2±2.5	4.15	3.52
Scalyhead sculpin, A. harringtoni	8	2(25.0)	6	4.5±0.8	3.8±0.8	0.02±0.03	6.5±3.9	1.95	1.64
Smoothhead sculpin, A. lateralis	66	9(13.6)	57	4.9±1.7	4.2±1.1	0.18±0.41	3.3±4.1	3.78	3.40

Appendix 6.9 (Contd.) b. Fish stomach contents statistics for nearshore fish...

Rosylip sculpin, Ascelichthys rhodorus	83	19(22.9)	64	4.6±1.6	3.3±1.5	0.07±0.10	3.2±3.3	3.82	4.25
Silverspotted sculpin, Blepsias cirrhosus	32	0(0)	32	6.2±1.0	3.8±1.5	0.10±0.07	8.3±8.4	2.62	2.99
Sharpnose sculpin, Clinocottus acuticeps	30	2(6.7)	28	4.4±1.6	3.6±1.4	0.01±0.02	5.0±6.2	3.30	2.84
Calico sculpin, C. embryum	30	0(0)	30	5.7±1.2	4.3±1.2	0.01±0.01	11.5±12.8	3.24	3.09
Mosshead sculpin, C. globiceps	72	9(12.5)	63	5.3±1.4	3.9±1.4	0.02±0.03	9.6±16.9	3.56	2.55
Buffalo sculpin, Enophrys bison	11	4(36.4)	7	5.6±1.9	4.6±0.8	1.75±2.50	9.0±10.1	1.91	0.81
Red Irish lord, juv., Hemilepidotus hemilepidotus	1	0(0)	1	5.0	5.0	0.18	5.0	1.92	0.91
Pacific staghorn sculpin Leptocottus armatus	65	1(1.5)	64	5.6 1.4	4.3±1.1	2.30±3.97	41.8±81.5	2.13	4.19
Great sculpin Myoxocephalus polyacanthocephalus	4	2(50.0)	2	5.0 1.4	5.0±0.0	0.35±0.34	7.5±3.5	0.91	0.53
Tidepool sculpin Oligocottus maculosus	187	7(3.7)	180	5.4±1.3	3.9±1.2	0.04±0.05	18.3±26.2	2.72	5.06
Saddleback sculpin, O. rimensis	28	2(7.1)	26	4.5±1.2	4.1±0.9	0.01±0.01	9.3±8.1	2.18	1.78
Fluffy sculpin, O. snyderi	96	3(3.1)	93	4.9±1.5	3.5±1.5	0.03±0.05	12.6±29.5	2.37	3.44
Manacled sculpin, Synchirus gilli	1	0(0)	1	3.0	5.0	< 0.0	13.0	0.00	0.00
Cabezon juv., Scorpaenichthys marmoratus	1	0(0)	1	6.0	3.0	0.20	12.0	1.04	0.25
Roughback sculpin, Chitonotis pugetensis	1	0(0)	1	6.0	5.0	0.18	4.0	0.81	0.79
Tadpole sculpin, Psychrolutes paradoxus	1	0(0)	1	6.0	5.0	0.04	3.0	0.92	0.32
Warty poacher, Ocella verrucosa	5	0(0)	5	6.2±0.8	5.0±0.0	0.05±0.05	14.4±8.3	1.74	1.44
Tubenose poacher, Pallasina barbata	29	4(13.8	25	4.2±2.0	3.6±1.6	0.01±0.01	3.8±7.6	2.37	2.09
Ribbon snailfish, Liparis cyclopus	1	0(0)	1	6.0	4.0	0.15	23.0	0.77	1.46
Tidepool snailfish, L. florae	33	0(0)	33	5.2±1.4	4.1±0.9	0.10±0.9	17.0±18.8	2.01	2.31
Ribbon snailfish, L. rutteri	2	0(0)	2	6.5±0.7	5.0±0.0	0.17±0.18	38.0±43.8	0.73	0.93
Kelp perch, Brachyistius frenatus	10	6(60)	4	2.5±0.6	2.0±1.4	0.01±0.01	10.7±8.2	0.00	0.00
Shiner perch, Cymatogaster aggregata	16	11(68.8)	5	4.6±1.1	2.6±1.5	0.11±0.07	109.2±104.0	1.17	1.14
Striped seaperch juv., Embiotoca lateralis	13	3(23.1)	10	3.4±1.3	4.2±1.2	0.04±0.03	12.1±9.1	0.92	0.24
Pile perch, Rhacochilus vacca	21	7(33.3)	14	3.6±1.0	2.8±1.3	0.05±0.03	50.4±70.5	1.18	1.66
Redtail surfperch, Amphisticus rhodoterus	26	4(16.7)	20	3.3±1.6	4.6±0.7	0.48±0.74	13.0±12.3	3.08	2.90
Pacific sandfish, Trichodon trichodon	1	0(0)	1	3.0	1.0	0.06	0.0*	0.00	0.00

Appendix 6.9 (Contd.) b. Fish stomach contents statistics for nearshore fish...

High cockscomb, *Anoplarchus purpurescens*	77	21(27.3)	56	4.6±1.6	3.5±1.4	0.02±0.02	27.6±133.7	2.04	4.00
Ribbon prickleback, *Phytichthys chirus*	31	2(6.5)	29	4.6±1.5	4.5±1.0	0.04±0.04	6.1±5.4	3.58	3.60
Black prickleback, *Xiphister atropurpureus*	55	27(49.1)	28	4.0±1.4	3.5±1.1	0.14±0.39	5.8±8.6	3.42	2.62
Rock prickleback, *X. mucosus*	36	11(306)	25	5.4±1.7	4.4±1.0	0.82±1.46	18.4±35.2	2.52	1.24
Penpoint gunnel, *Apodichthys flavidus*	54	33(61.1)	21	3.5±1.3	4.2±1.2	0.01±0.02	15.4±36.4	1.62	2.19
Crescent gunnel, *Pholis laeta*	70	22(314)	48	4.6±1.8	4.4±1.3	0.02±0.02	19.7±35.7	2.99	3.06
Saddleback gunnel, *P. ornata*	3	0(0)	3	4.3±1.5	5.0±0.0	0.02±0.02	10.3±11.4	1.22	1.28
Pacific sand lance juv., *Ammodytes hexapterus*	6	2(33.3)	4	6.3±0.5	2.3±1.3	0.02±0.01	7.5±11.7	0.47	0.08
Speckled sanddab, *Citharichthys stigmaeus*	55	14(25.5)	41	5.1±2.0	4.5±1.1	0.15±0.15	18.0±29.9	3.65	3.51
English sole juv., *Parophrys vetulus*	71	4(5.6)	67	5.0±1.6	4.4±1.2	0.09±0.10	33.3±47.2	3.02	3.03
Starry flounder, *Platichthys stellatus*	18	5(27.8)	13	4.6±1.6	4.5±0.9	1.71±2.71	16.6±26.5	1.95	1.89
C-O sole, *Pleuronichthys coenosus*	2	0(0)	2	6.5±0.7	5.0±0.0	3.58±4.39	7.5±6.6	0.91	0.29
Sand sole juv., *Psettichthys melanostictus*	76	12(15.8)	64	4.7±1.8	4.5±0.9	0.48±0.99	19.8±30.1	2.74	2.68
Total	1754	304(17.3)	1450						

APPENDIX 6.10 DIET SPECTRA OF NEARSHORE FISH COLLECTED DURING 1978

Similar information from 1976 and 1977 was contained in Simenstad et al. 1977 and Cross et al. 1978, respectively.

Spiny dogfish, Squalus acanthias. Four of the five captured in a Port Townsend townet haul contained food items, including hyperiid amphipods, ctenophores, nereid polychaetes, crab (Porcellanidae) larvae and pieces of algae (Chlorophyta).

Big skate, Raja binoculata. One specimen captured in a Dungeness Spit beach-seine sample had consumed two crangonid shrimp, Crangon stylirostris.

Pacific herring, Clupea harengus pallasi (juvenile). This species was captured in abundance at five of the seven townet sites (not Beckett Point and Dungeness Spit) and in two of the beach-seine collections (Morse Creek and Dungeness Spit). Their prey composition was essentially identical to that reported in previous years. Of the total FRI, calanoid copepods made up 97.86%, and the only other prey organism of any consequence was pelagic ostracods (Fig. 10-1).

Chum salmon, Oncorhynchus keta (juvenile). This species was collected principally during two townet collections at Beckett Point and Morse Creek. Ten of the thirteen, however, had empty stomachs. The three specimens with identifiable stomach contents had consumed mainly calanoid copepods and just a few larval mysids.

Coho salmon, Oncorhynchus kisutch (juvenile). One specimen from the Beckett Point townet collections had three polychaete annelids and pieces of unidentified algae in its stomach.

Chinook salmon, Oncorhynchus tshawytscha (juvenile). Samples originated from both beach-seine and townet collections at Beckett Point and Kydaka Beach. The total prey spectrum was rather evenly proportioned between drift insects (Diptera, Coleoptera, Hymenoptera) and brachyuran crab larvae (megalops).

Rainbow (steelhead) trout, Salmo gairdneri (juvenile). One specimen from the Morse Creek beach-seine collections had consumed three juvenile fishes (98.03% of the total identifiable biomass), one insect, and one isopod, Gnorimosphaeroma oregonensis.

Night smelt, Spirinchus starksi (juvenile). Caught for the first time during the MESA nearshore fish collections in the Strait of Juan de Fuca, this species was found in the townet collections in August. A sample of ten

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INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA
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                  (PACIFIC HERRING      )  ADJUSTED SAMPLE SIZE =  63
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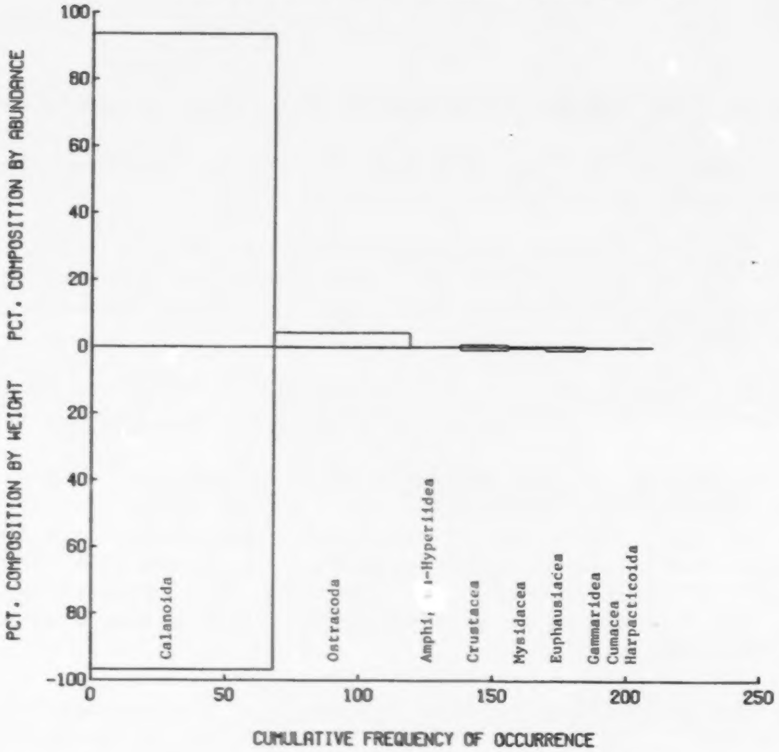

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                                  FREQ   NUM.   GRAV.   PREY    PERCENT
          PREY ITEM               OCCUR  COMP.  COMP.   I.R.I.  TOTAL IRI
-----------------------------     -----  -----  -----   ------  ---------

CALANOIDA                         68.25  93.69  96.87 13006.7     97.86
OSTRACODA                         50.79   4.27    .16   225.2      1.69
AMPHIPODA-HYPERIIDEA              19.05    .12    .02     2.7       .02
CRUSTACEA                         17.46    .73    .85    27.5       .21
MYSIDACEA                         14.29    .24    .25     7.1       .05
EUPHAUSIACEA                      14.29    .24    .90    16.3       .12
GAMMARIDEA                        11.11    .10    .13     2.6       .02
CUMACEA                            7.94    .09    .01      .7       .01
HARPACTICOIDA                      6.35    .06    .01      .4       .00

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

     PERCENT DOMINANCE INDEX             .63    .94                .96
     SHANNON-WEINER DIVERSITY            .45    .28                .18
     EVENNESS INDEX                      .12    .08                .05
```

Fig. 10-1. IRI prey spectrum of juvenile Pacific herring from Strait of Juan de Fuca, August 1978.

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from Pillar Point had only three with identifiable stomach contents. These three had fed on gammarid amphipods (57.14% of the total identifiable biomass), calanoid copepods, euphausiids, and mysids.

Plainfin midshipman, Porichthys notatus. One adult from Beckett Point had an empty stomach.

Northern clingfish, Gobiesox maeandricus. This fish was commonly found in intertidal collections in both rocky tidepool and cobble intertidal habitats. Acmaeid limpets (Notoacmaea persona, N. scutum, Collisella pelta) at 70.92% of the total IRI dominated the prey spectrum (Fig. 10-2). Supplemental contributions were also made by gammarid amphipods, sphaeromatid isopods (mainly Exosphaeroma amplicauda, but also Gnorimosphaeroma oregonensis and Dynamenella sheareri), polychaete annelids (sabellarids), and harpacticoid copepods.

Pacific tomcod, Microgadus proximus (juvenile). Three eastern Strait of Juan de Fuca sites--Beckett Point, Port Williams, and Morse Creek--produced high catches. Total IRI prey spectrum was rather evenly split between hippolytid shrimp and mysids (Fig. 10-3); secondary prey was gammarid amphipods (14 Accedomoera vagor, four Mandibulophoxus gilesi, one Monoculodes sp., and one Synchelidium shoemakeri). One juvenile sand sole made up 23.47% of the total identifiable biomass.

Threespine stickleback, Gasterosteus aculeatus. The stomach of one specimen collected in a Port Williams beach-seine collection was empty.

Tube-snout, Aulorhynchus flavidus. This species was fairly restricted to the collections in the eastern end of the strait, especially at Beckett Point and Morse Creek. Juvenile hippolytid shrimp, 65.21% of the total IRI, and harpacticoid copepods, 33.20%, were the only prey of consequence.

Bay pipefish, Syngnathus leptorhynchus. Of seven captured in the Beckett Point beach-seine collections, all had empty stomachs but one, which contained two juvenile hippolytid shrimp.

Widow rockfish, Sebastes entomelas (juvenile). In the three years of MESA collections in the strait, the only time this species was captured in any abundance was August 1978. They were especially common in beach-seine collections at Morse Creek and Beckett Point and townet collections at Kydaka Beach. The composite IRI prey spectrum (Fig. 10-4) is dominated by both epibenthic hippolytid shrimp and calanoid copepods, 60.96% and 36.53% of the total IRI, respectively. The gammarid amphipods, which constituted only 1.21% of the total IRI, were mainly Accedomoera vagor but also Anisogammarus pugettensis, Melita desdichata, Najna consiliorium, Hyale rubra, Parallorchestes ochotensis, and Podoceropsis sp. However, examination of the prey composition of samples from specific sites shows that the diet becomes more specific and typically less diverse. The specimens from the Kydaka Beach townet collections had consumed calanoid copepods almost exclusively while the Beckett Point beach-seine sample had a prey spectrum almost completely dominated by hippolytid shrimp. The Morse Creek sample had the most diverse prey composition, including most of the gammarid amphipods.

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INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA
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               (N. CLINGFISH         )  ADJUSTED SAMPLE SIZE =  49
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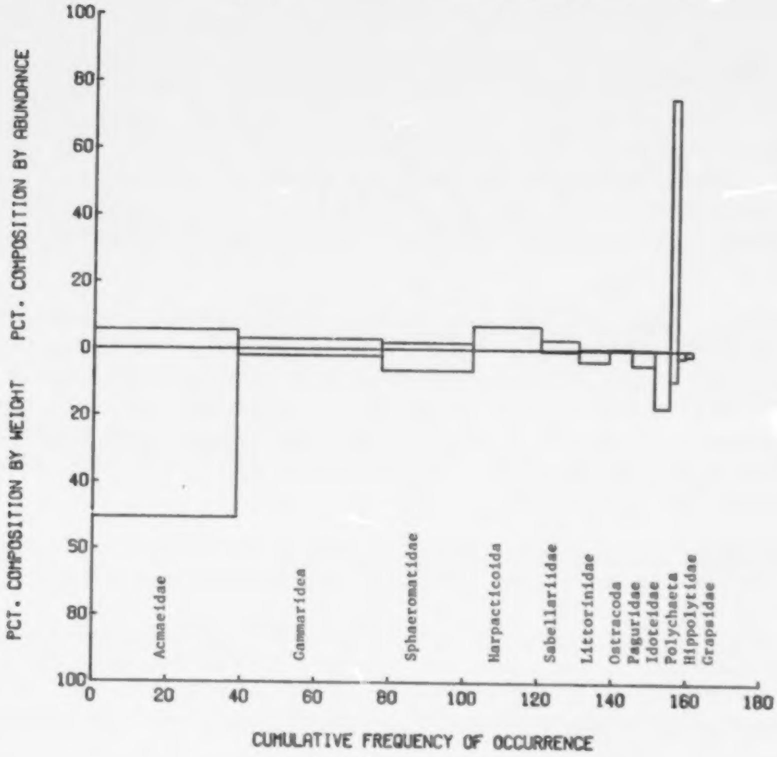

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                                  FREQ   NUM.   GRAV.   PREY     PERCENT
         PREY ITEM                OCCUR  COMP.  COMP.   I.R.I.   TOTAL IRI
-----------------------------     -----  -----  -----   ------   ---------

ACMAEIDAE                         38.78   5.58  50.67   2181.0     70.92
GAMMARIDEA                        38.78   3.09   1.97    196.1      6.39
SPHAEROMATIDAE                    24.49   1.96   6.40    204.7      6.65
HARPACTICOIDA                     18.37   7.01    .03    129.2      4.20
SABELLARIIDAE                     10.20   2.94    .37     33.8      1.10
LITTORINIDAE                       8.16    .38   3.48     31.5      1.02
OSTRACODA                          6.12    .53    .01      3.3       .11
PAGURIDAE                          6.12    .30   4.44     29.0       .94
IDOTEIDAE                          4.08    .23  17.28     71.4      2.32
POLYCHAETA                         2.04  75.36   9.03    172.2      5.60
HIPPOLYTIDAE                       2.04    .08   2.16      4.6       .15
GRAPSIDAE                          2.04    .08   1.47      3.2       .10

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

     PERCENT DOMINANCE INDEX               .58    .30                  .52
     SHANNON-WEINER DIVERSITY             1.57   2.45                 1.71
     EVENNESS INDEX                        .34    .53                  .37
```

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Fig.10-2. IRI prey spectrum of northern clingfish from Strait of Juan de Fuca, 1978.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION AL6TA
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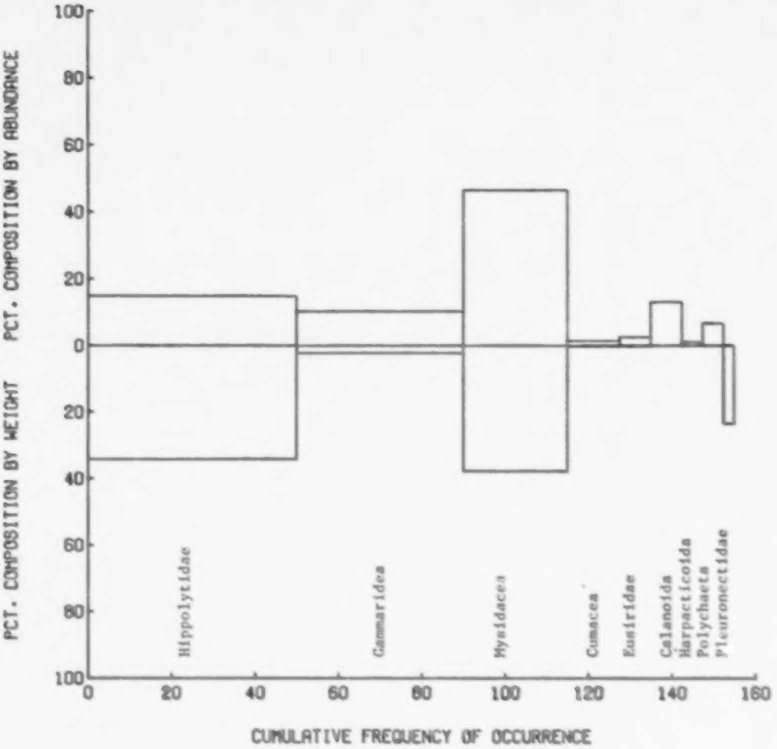
(PACIFIC TOMCOD) ADJUSTED SAMPLE SIZE = 40



```
                                     FREQ   NUM.   GRAV.   PREY     PERCENT
         PREY ITEM                   OCCUR  COMP.  COMP.   I.R.I.   TOTAL IRI
 ----------------------------        -----  -----  -----   ------   ---------

HIPPOLYTIDAE                         50.00  14.85  34.14   2449.6     46.12
GAMMARIDEA                           40.00  10.29   2.25    501.2      9.44
MYSIDACEA                            25.00  44.49  37.83   2108.0     39.69
CUMACEA                              12.50   1.47    .19     20.7       .39
EUSIRIDAE                             7.50   2.61    .13     20.5       .39
CALANOIDA                             7.50  13.05    .00     97.9      1.84
HARPACTICOIDA                         5.00   1.14    .00      5.7       .11
POLYCHAETA                            5.00   6.69    .01     33.5       .63
PLEURONECTIDAE                        2.50    .16  23.47     59.1      1.11

  PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
  COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
  (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

     PERCENT DOMINANCE INDEX                .27    .32                .39
     SHANNON-WEINER DIVERSITY              2.50   1.87               1.70
     EVENNESS INDEX                         .55    .41                .37
```

Fig.10-3. **IRI prey spectrum of juvenile Pacific tomcod from Strait of Juan de Fuca, August 1978.**

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INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA
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               (WIDOW ROCKFISH        )  ADJUSTED SAMPLE SIZE =  32
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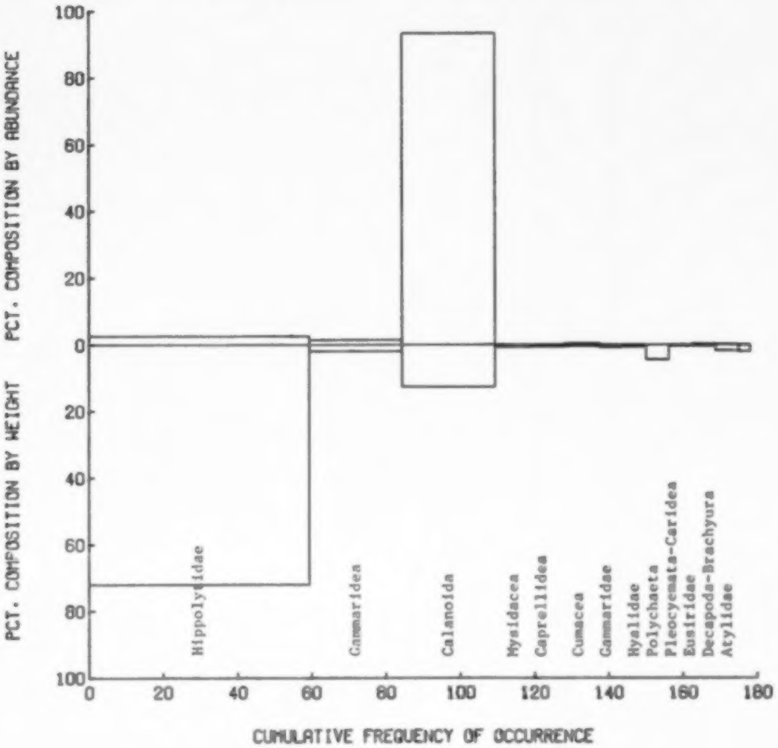

```
                                   FREQ   NUM.   GRAV.   PREY     PERCENT
        PREY ITEM                  OCCUR  COMP.  COMP.   I.R.I.   TOTAL IRI
----------------------------       -----  -----  -----   ------   ---------

HIPPOLYTIDAE                       59.38   2.59  72.03   4430.0     60.95
GAMMARIDEA                         25.00   1.50   2.02     87.9      1.21
CALANOIDA                          25.00  93.46  12.72   2654.7     36.53
MYSIDACEA                           9.38    .12    .72      7.9       .11
CAPRELLIDEA                         9.38    .17    .65      7.6       .11
CUMACEA                             9.38    .46    .45      8.6       .12
GAMMARIDAE                          6.25    .09    .81      5.6       .08
HYALIDAE                            6.25    .17    .68      5.3       .07
POLYCHAETA                          6.25    .08   4.45     28.3       .39
PLEOCYEMATA-CARIDEA                 6.25    .08    .32      2.5       .04
EUSIRIDAE                           6.25    .37    .42      5.0       .07
DECAPODA-BRACHYURA                  6.25    .25   1.82     12.9       .18
ATYLIDAE                            3.13    .12   2.01      6.7       .09

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX              .87    .54                .51
      SHANNON-WIENER DIVERSITY             .54   1.63               1.17
      EVENNESS INDEX                       .12    .36                .25
```

Fig.10-4. IRI prey spectrum of juvenile widow rockfish from Strait of Juan de Fuca, August 1978.

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best available copy.

Kelp greenling, Hexagrammos decagrammus (juvenile). This fish was collected in both beach-seine and intertidal collections. Despite the low sample size, the diet composition was spread over pandalid and hippolytid shrimp, gammarid and caprellid amphipods, bivalves, and oxyrhynchan, brachyuran, and brachyrhynchan crabs. Pandalid crabs, at 13.24% of the total number of prey organisms and 50.17% of the prey biomass, were the single most important prey taxon.

Rock greenling, Hexagrammos lagocephalus (juvenile). Two were collected during intertidal sampling along the western end of the strait. One had consumed a gammarid amphipod and the other a caprellid amphipod.

Whitespotted greenling, Hexagrammos stelleri. An adult from Beckett Point had only pieces of plant material (probably eelgrass) in its stomach.

Lingcod, Ophiodon elongatus (juvenile). Captured during the beach-seine sampling at Kydaka Beach, six of the nine specimens had identifiable stomach contents. The majority of the contents--71.93% of total number of prey, 75.47% of the total prey biomass--was remains of fish; a mysid and a crangonid shrimp had also been eaten.

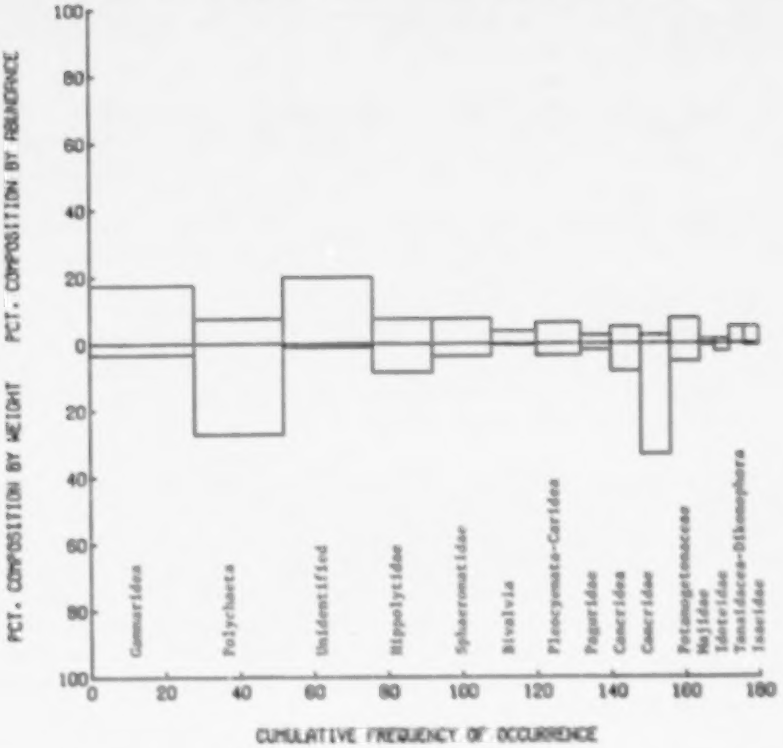
Padded sculpin, Artedius fenestralis. This species was most common in the beach-seine collections, especially at Beckett Point, Port Williams, and Twin Rivers. The prey spectrum (Fig. 10-5) was one of the most diverse; it had the highest value of the Shannon-Wiener diversity index based on prey numbers, and it was the seventh highest based on prey biomass. Polychaete annelids (26.72% of total IRI); gammarid amphipods (18.67%); wood, rock, and other debris (16.16%); cancrid crabs (12.79% of the total IRI combined and including *Cancer magister*); and hippolytid shrimp (8.27%) constituted the prevalent prey taxa.

Scalyhead sculpin, Artedius harringtoni. Specimens from Slip Point tidepool collections had fed mainly on gammarid amphipods (79.49% of total number of prey, 59.96% of total prey biomass), although one caridean shrimp contributed over 30% of the total prey biomass.

Smoothhead sculpin, Artedius lateralis. Collections at rocky tidepool sites at Slip Point, Observatory Point, and Neah Bay provided the highest number of samples. Gammarid amphipods, the most common prey, made up almost 70% of the total IRI (Fig.10-6). The gammarid *Atylus tridens* was the only identifiable species. Hippolytid shrimp (*Heptacarpus breviorstris*), 9.61% of the total IRI, and larval fish, 8.45%, constituted the prey of secondary importance.

Rosylip sculpin, Ascelichthys rhodorus. Twin Rivers was the only beach-seine site which produced considerable numbers of this species; however, they were common at a number of intertidal sites, including Slip Point, Twin Rivers, Morse Creek, and Neah Bay. Gammarid amphipods, 69.11% of the total IRI (*Melita desdichata*, *Pontogeneia ivanovi*, *Hyale* sp., *Parallorchestes ochotensis*, *Ischyrocerus* sp., *Orchestia* sp.) and sphaeromatid isopods, 13.30%, (*Gnorimosphaeroma oregonensis* and *Exosphaeroma amplicauda*) were the primary prey taxa. Polychaete annelids (7.45%), idoteid isopods (3.57%, *Synidotea pettiboneae*, *Idotea* sp.), mysids (2.54%), and juvenile brachyrhynchan crabs (2.70%) constituted secondary prey organisms (Fig.10-7).

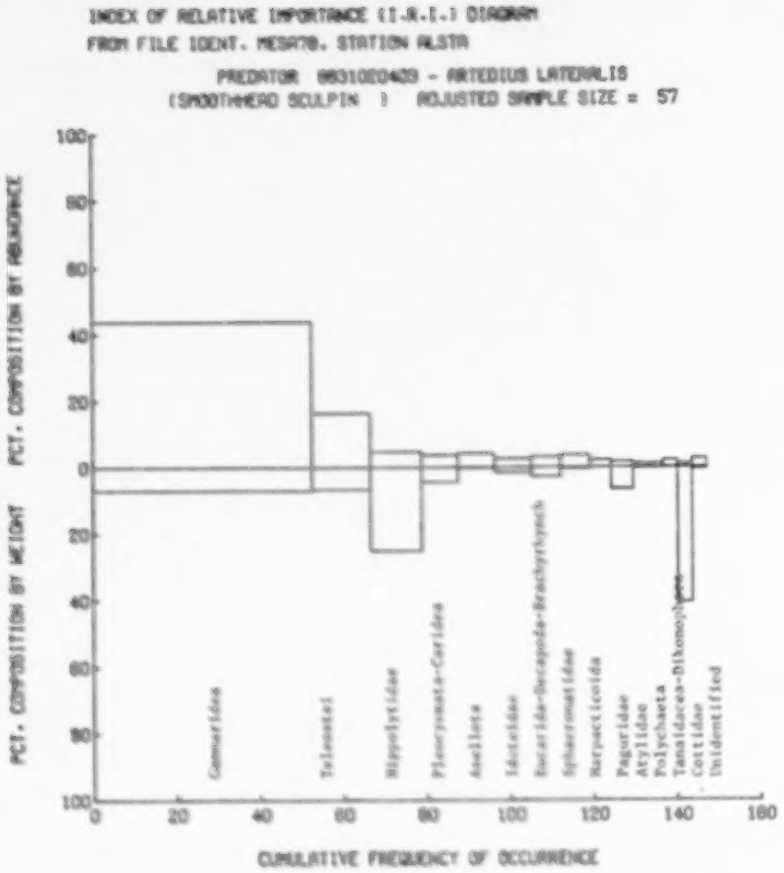
INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78, STATION ALSTA
PREDATOR 8831020401 - ARTEDIUS FENESTRALIS
(PADDED SCULPIN) ADJUSTED SAMPLE SIZE = 25



```
                                  FREQ   NUM.   GRAV.   PREY   PERCENT
        PREY ITEM                 OCCUR  COMP.  COMP.  I.R.I.  TOTAL IRI
 ---------------------------      -----  -----  -----  ------  ---------

 GAMMARIDEA                       28.00  17.50   3.30   582.4    18.67
 POLYCHAETA                       24.00   7.50  27.22   833.3    26.72
 UNIDENTIFIED                     24.00  20.00   1.00   503.9    16.16
 HIPPOLYTIDAE                     16.00   7.50   8.63   258.0     8.27
 SPHAEROMATIDAE                   16.00   7.50   3.79   180.6     5.79
 BIVALVIA                         12.00   3.75    .31    48.7     1.56
 PLEOCYEMATA-CARIDEA              12.00   6.25   3.37   115.4     3.70
 PAGURIDAE                         8.00   2.50   1.92    35.3     1.13
 CANCRIDEA                         8.00   5.00   8.26   106.1     3.41
 CANCRIDAE                         8.00   2.50  33.20   285.6     9.16
 POTAMOGETONACEAE                  8.00   7.50   5.41   103.3     3.31
 MAJIDAE                           4.00   1.25    .44     6.8      .22
 IDOTEIDAE                         4.00   1.25   2.30    14.2      .46
 TANAIDACEA-DIKONOPHORA            4.00   5.00    .05    20.2      .65
 ISAEIDAE                          4.00   5.00    .54    22.2      .71

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX              .11    .21              .16
      SHANNON-WEAVER DIVERSITY            3.53   2.74             3.06
      EVENNESS INDEX                       .90    .71              .78
```

Fig.10-5. IRI prey spectrum of padded sculpins from Strait of Juan de Fuca, 1978.

Reproduced from best available copy.



PREY ITEM	FREQ. OCCUR.	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	52.63	43.68	7.03	2668.9	69.86
TELEOSTEI	14.04	16.32	6.64	322.4	8.45
HIPPOLYTIDAE	12.28	4.74	25.15	367.0	9.61
PLEUROCYEMATA-CARIDEA	8.77	3.68	4.49	71.7	1.88
AMPELISCA	8.77	4.21	.12	38.0	1.00
IDOTEIDAE	8.77	2.63	1.53	36.5	.96
EUCARIDA-DECAPODA-BRACHYRHYNCH	7.02	3.16	2.86	42.3	1.11
SPHAEROMATIDAE	7.02	3.68	.38	28.6	.76
HARPACTICOIDA	5.26	2.11	.00	11.1	.29
PAGURIDAE	5.26	1.58	6.67	43.4	1.14
ATYLIDAE	3.51	1.05	.16	4.2	.11
POLYCHAETA	3.51	1.05	.12	4.1	.11
TANAIDACEA-DIKONOPHORA	3.51	2.11	.03	7.5	.20
COTTIDAE	3.51	1.05	41.55	149.5	3.92
UNIDENTIFIED	3.51	2.63	.40	10.6	.28

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.23	.26	.51
SHANNON-WEINER DIVERSITY	3.19	2.86	1.76
EVENNESS INDEX	.88	.56	.37

Fig.10-6. IRI prey spectrum of smoothhead sculpins from the Strait of Juan de Fuca, 1978.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
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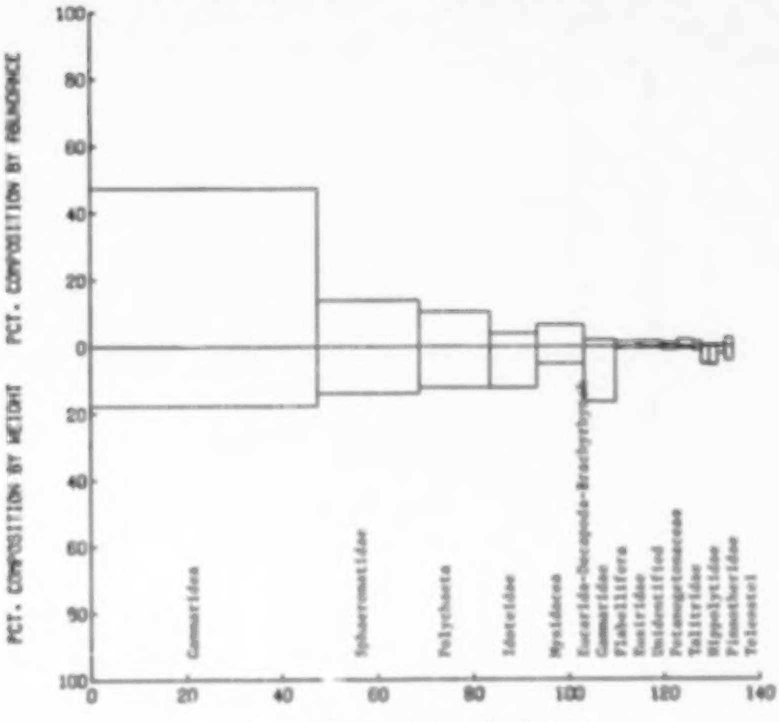

CUMULATIVE FREQUENCY OF OCCURRENCE

PREY ITEM	FREQ. OCCUR.	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	47.54	47.29	17.03	3058.9	68.75
SPHAEROMATIDAE	21.31	13.79	14.08	593.9	13.35
POLYCHAETA	14.75	10.34	12.32	334.3	7.51
IDOTEIDAE	9.84	3.94	12.41	160.9	3.62
MYSIDACEA	9.84	6.90	5.22	119.3	2.68
EUCARIDA-DECAPODA-BRACHYRHYNCH	6.56	1.97	16.56	121.6	2.73
GAMMARIDAE	4.92	1.48	.41	9.3	.21
FLABELLIFERA	4.92	1.48	.46	9.5	.21
KUSIIDAE	3.28	.99	1.01	6.6	.15
UNIDENTIFIED	3.28	1.97	.61	8.5	.19
POTAMOGETONACEAE	1.64	1.48	1.11	4.2	.10
TALITRIDAE	1.64	.49	5.17	9.3	.21
HIPPOLYTIDAE	1.64	.49	5.47	9.8	.22
PINNOTHERIDAE	1.64	.49	2.08	4.2	.09
TELEOSTEI	1.64	2.46	4.15	10.8	.24

(PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.26	.17	.50
SHANNON-WEAVER DIVERSITY	2.85	3.35	1.65
EVENNESS INDEX	.62	.73	.36

Fig. 10-7. IRI prey spectrum of rosylip sculpin from the Strait of Juan de Fuca, 1978.

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Silverspotted sculpin, Blepsis cirrhosus. Specimens originated mainly in beach-seine collections at Morse Creek and Twin Rivers. Gammarid amphipods and mysids, with combined contributions of 55.60% and 39.36% of the total IRI, respectively, and sphaeromatid isopods, 4.05% (Gnorimosphaeroma oregonensis), were the only other prey of significance (Fig. 10-8).

Sharpnose sculpin, Clinocottus acuticeps. This fish was typically found in the cobble intertidal habitats at Morse Creek and Twin Rivers. Epibenthic crustaceans composed the majority of the diet (Fig. 10-9). Gammarid amphipods, sphaeromatid isopods (Gnorimosphaeroma oregonensis, Exosphaeroma amplicauda, Dynamenella sheareri), dipteran insects, harpacticoid copepods, and idoteid isopods made up approximately the same proportions of the total number of prey, but gammarid amphipods (56.50% of the total IRI) and sphaeromatid isopods (27.07%) would have to be considered more important by biomass.

Calico sculpin, Clinocottus embryum. While C. acuticeps were found mainly in the cobble intertidal habitats, C. embryum were typically collected in the rocky tidepool habitats at Slip Point and Observatory Point. Specimens were also collected at Morse Creek. Accordingly, barnacle cirri were prominent components of the prey spectrum (60.46% of the total IRI). Gammarid amphipods (17.79%), harpacticoid copepods (9.79%), insect larvae (4.81%), and sphaeromatid isopods (3.77%, Exosphaeroma amplicauda) followed in importance as prey (Fig. 10-10).

Mosshead sculpin, Clinocottus globiceps. Intertidal collections at Morse Creek, Slip Point, and Observatory Point produced substantial numbers of specimens. Like C. embryum, C. globiceps appears to be most common in rocky tidepool habitats. Prey includes harpacticoid copepods, barnacle cirri, and gammarid amphipods. The alga Ulotrichales, which includes Ulva sp., composed the greatest proportion of the total IRI (69.94%), mostly because of high biomass contribution (74.23%). It is not known whether algae are utilizable food for the sculpin, or whether they are consumed incidentally with other prey (Fig. 10-11).

Buffalo sculpin, Enophrys bison. Juveniles were captured by beach seine at Morse Creek, Port Williams, and Twin Rivers, and in intertidal collections at Slip Point and Observatory Point. Algae (Ulotrichales) accounted for 76.19% of the number of prey items and 97.45% of the total prey biomass, and, according to other documentation of buffalo sculpin's prey spectrum (Miller et al. 1977, Cross et al. 1978, Fresh et al. 1979), may actually be a food resource. The only other food items of consequence were gammarid amphipods, 17.46% of the total number of prey.

Red Irish lord, Hemilepidotus hemilepidotus. One juvenile collected in a Slip Point tidepool had consumed one crab, Lophopanopeus bellus (79.26% of total prey biomass), two sphaeromatid isopods, Exosphaeroma amplicauda (17.02% of total prey biomass), and incidental pieces of wood and algae.

Staghorn sculpin, Leptocottus armatus. This species was common at all beach-seine sites. Sixty-eight percent of samples were juveniles. Mysids (Archaeomysis grebnitzki) dominated the diverse prey spectrum (Fig. 10-12) because of high contribution (80.85%) to the total number of food items. Cancrid crabs (Cancer magister) and fishes (Microgadus proximus, Psettichthys

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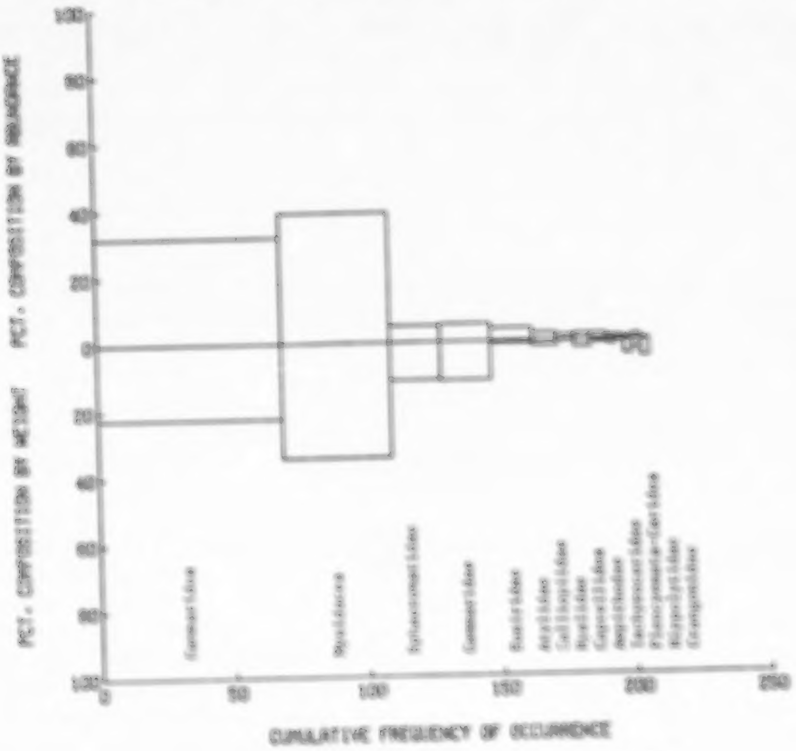

PREY ITEM	FREQ. OCCUR.	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
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[illegible]

[illegible] DOMINANCE INDEX	[illegible]	[illegible]			[illegible]
[illegible] DIVERSITY	[illegible]	[illegible]			[illegible]
EVENNESS INDEX	[illegible]	[illegible]			[illegible]

Fig.10-8. IRI prey spectrum of silverspotted sculpin from Strait of Juan de Fuca, August 1978.

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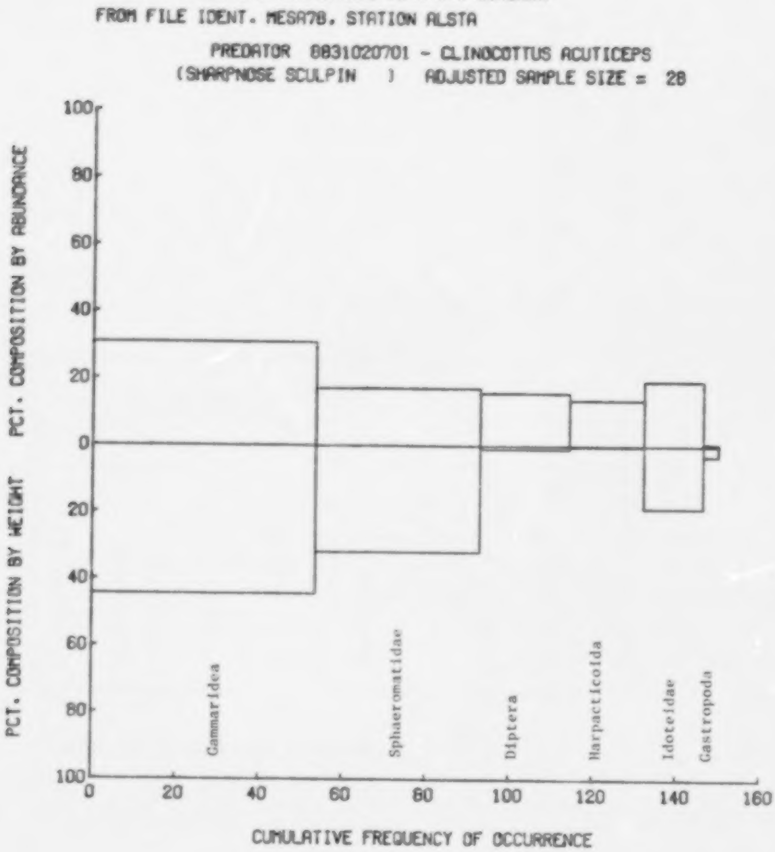

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                                  FREQ   NUM.   GRAV.   PREY     PERCENT
         PREY ITEM                OCCUR  COMP.  COMP.   I.R.I.   TOTAL IRI
-----------------------------     -----  -----  -----   ------   ---------

GAMMARIDEA                        53.57  30.71  44.45   4026.5     56.50
SPHAEROMATIDAE                    39.29  17.14  31.96   1929.1     27.07
DIPTERA                           21.43  15.71    .95    357.1      5.01
HARPACTICOIDA                     17.86  13.57    .14    244.9      3.44
IDOTEIDAE                         14.29  14.29  18.70    542.6      7.61
GASTROPODA                         3.57    .71   3.16     13.9       .19

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

     PERCENT DOMINANCE INDEX                .20    .34                .40
     SHANNON-WEINER DIVERSITY              2.48   1.79               1.68
     EVENNESS INDEX                         .75    .54                .51
```

Fig. 10-9. IRI prey spectrum of sharpnose sculpin from Strait of Juan de Fuca, 1978.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
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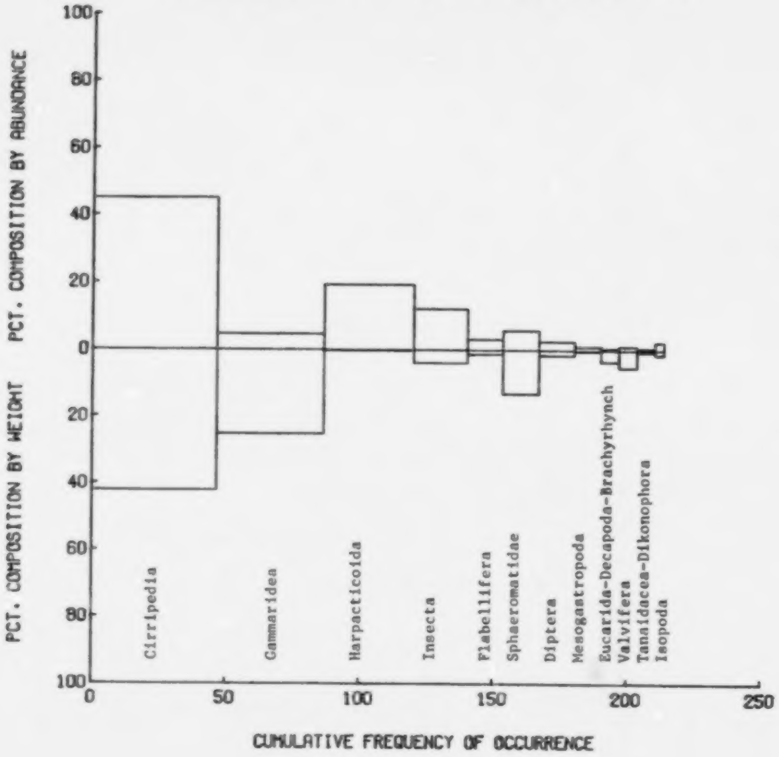
PREDATOR 8831020702 - CLINOCOTTUS EMBRYUM
(CALICO SCULPIN) ADJUSTED SAMPLE SIZE = 30



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                                    FREQ   NUM.   GRAV.   PREY    PERCENT
         PREY ITEM                  OCCUR  COMP.  COMP.   I.R.I.  TOTAL IRI
 -------------------------------    -----  -----  -----   ------  ---------

CIRRIPEDIA                          46.67  45.06  42.12   4068.5    60.46
GAMMARIDEA                          40.00   4.65  25.29   1197.5    17.79
HARPACTICOIDA                       33.33  19.46    .29    659.0     9.79
INSECTA                             20.00  12.21   3.96    323.4     4.81
FLABELLIFERA                        13.33   3.20   1.20     58.7      .87
SPHAEROMATIDAE                      13.33   5.81  13.23    253.9     3.77
DIPTERA                             13.33   2.62   1.50     54.9      .81
MESOGASTROPODA                      10.00   1.16    .35     15.1      .23
EUCARIDA-DECAPODA-BRACHYRHYNCH       6.67    .58   3.52     27.3      .41
VALVIFERA                            6.67   1.16   5.28     43.0      .64
TANAIDACEA-DIKONOPHORA               6.67    .58    .59      7.9      .12
ISOPODA                              3.33   2.33   1.47     12.6      .19

  PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
  COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
  (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

    PERCENT DOMINANCE INDEX                   .26    .27                .41
    SHANNON-WEINER DIVERSITY                 2.54   2.43               1.86
    EVENNESS INDEX                            .65    .62                .47
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Fig. 10-10. IRI prey spectrum of calico sculpin from Strait of Juan de Fuca, 1978.

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INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
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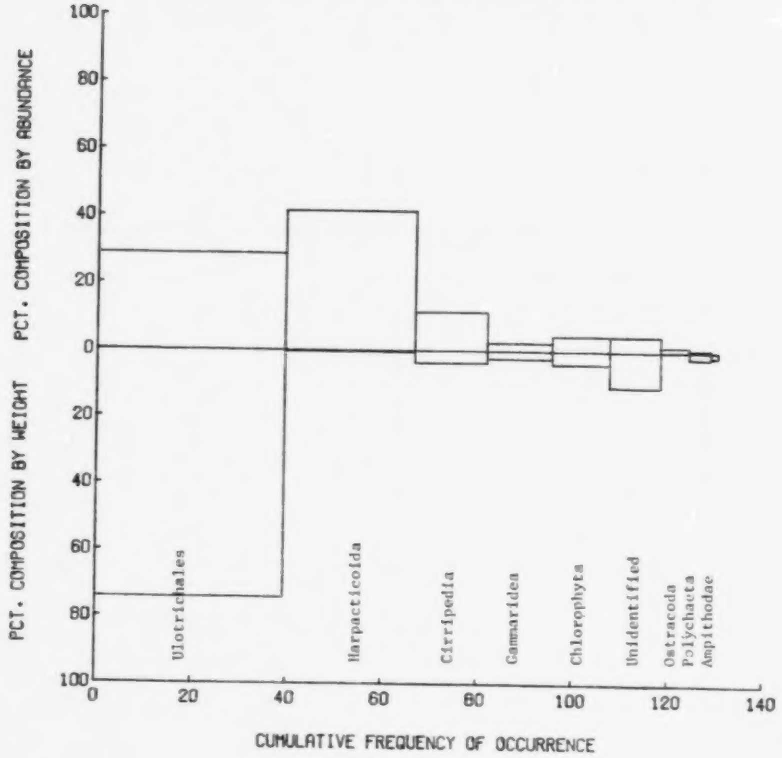

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                                  FREQ   NUM.    GRAV.   PREY     PERCENT
         PREY ITEM                OCCUR  COMP.   COMP.   I.R.I.   TOTAL IRI
 ----------------------------     -----  -----   -----   ------   ---------

ULOTRICHALES                      39.39  28.78   74.23   4058.1     69.94
HARPACTICOIDA                     27.27  41.63     .37   1145.4     19.74
CIRRIPEDIA                        15.15  11.54    3.67    230.5      3.97
GAMMARIDEA                        13.64   2.44    2.31     64.9      1.12
CHLOROPHYTA                       12.12   4.55    3.93    102.9      1.77
UNIDENTIFIED                      10.61   4.55   10.83    163.1      2.81
OSTRACODA                          6.06   1.46     .04      9.1       .16
POLYCHAETA                         4.55    .65    2.10     12.5       .22
AMPITHOIDAE                        1.52    .16    1.60      2.7       .05

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX                .27     .57                .53
      SHANNON-WEINER DIVERSITY              2.41    1.48               1.39
      EVENNESS INDEX                         .57     .35                .33
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Fig. 10-11. IRI prey spectrum of mosshead sculpin from Strait of Juan de Fuca, 1978.

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INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
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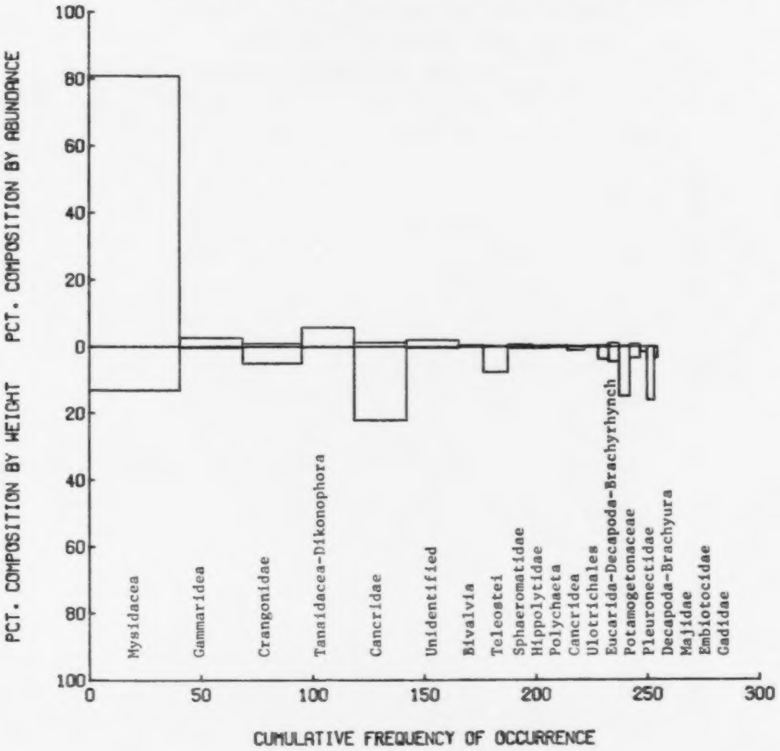

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                                    FREQ    NUM.    GRAV.   PREY     PERCENT
         PREY ITEM                  OCCUR   COMP.   COMP.   I.R.I.   TOTAL IRI
 ----------------------------      -----   -----   -----   ------   ---------

 MYSIDACEA                          40.63   80.95   13.22   3821.2     74.34
 GAMMARIDEA                         28.13    2.69     .32     84.8      1.65
 CRANGONIDAE                        26.56     .97    5.07    160.5      3.12
 TANAIDACEA-DIKONOPHORA             23.44    5.76     .11    137.6      2.68
 CANCRIDAE                          23.44    1.27   22.19    549.9     10.70
 UNIDENTIFIED                       23.44    2.02     .30     54.5      1.06
 BIVALVIA                           10.94     .60     .03      6.9       .13
 TELEOSTEI                          10.94     .26    7.66     86.7      1.69
 SPHAEROMATIDAE                     10.94     .71     .37     11.8       .23
 HIPPOLYTIDAE                        7.81     .37     .40      6.0       .12
 POLYCHAETA                          7.81     .34     .14      3.8       .07
 CANCRIDEA                           7.81     .22    1.08     10.2       .20
 ULOTRICHALES                        6.25     .34     .09      2.7       .05
 EUCARIDA-DECAPODA--BRACHYRHYNCH     4.69     .37    3.79     19.5       .38
 POTAMOGETONACEAE                    4.69    1.05    4.59     26.4       .51
 PLEURONECTIDAE                      4.69     .26   14.91     71.1      1.38
 DECAPODA-BRACHYURA                  4.69     .82    3.49     20.2       .39
 MAJIDAE                             3.13     .07    1.54      5.0       .10
 EMBIOTOCIDAE                        3.13     .11   16.16     50.9       .99
 GADIDAE                             1.56     .04    3.36      5.3       .10

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX                .66     .13                 .57
      SHANNON-WEINER DIVERSITY              1.40    3.34                1.59
      EVENNESS INDEX                         .29     .67                 .32
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Fig.10-12. **IRI prey spectrum of staghorn sculpin from Strait of Juan de Fuca, August 1978.**

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melanostictus, Embiotocidae, Pleuronectidae) made up a large proportion (15.55%) of the remaining IRI as a result of their high biomass contributions. Mysids, gammarid amphipods, and crangonid shrimp were the three most frequently occurring prey in the sample.

Great sculpin, Myoxocephalus polyacanthocephalus. Hippolytid shrimp constituted the primary prey item (80.00% of total number, 90.78% of total biomass) in the stomachs of two of four specimens collected by beach seine at Beckett Point; several caprellid amphipods and fish bones also occurred in the stomach contents.

Tidepool sculpin, Oligocottus maculosus. The most common and widely distributed cottid in the intertidal habitats along the strait, this fish was collected at all the intertidal sites; it also occurred in abundance at Beckett Point and Port Williams. Epibenthic crustaceans composed the bulk (91% of total IRI combined) of the prey spectrum (Fig. 10-13). Harpacticoid copepods because of their numbers accounted for over 66% of the total IRI, while gammarid amphipods and sphaeromatid isopods contributed more to the gravimetric composition. Species of gammarid amphipods, in order of decreasing numerical importance, were Melita desdichata, Hyale rubra, Aoroides columbiae, Parallorchestes ochotensis, Calliopiella pratti, and Photis sp. Sphaeromatid isopods were mainly Gnorimosphaeroma oregonensis (62% of those identified), Dynamenella sheareri (20%), and Exosphaeroma amplicauda (18%). Hippolytid shrimp, brachyrhynchan crabs (Hemigrapsus nudus, H. oregonensis), barnacles, archaeogastropods (acmaeid limpets), fish, and pagurid crabs also made considerable contributions to the total prey biomass but were otherwise unimportant.

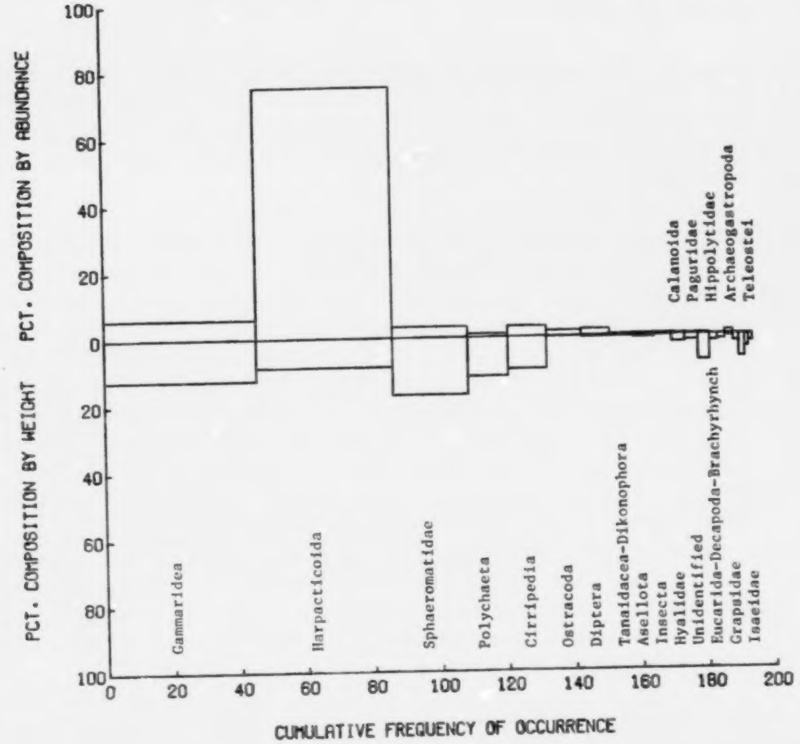
Saddleback sculpin, Oligocottus rimensis. This species was captured in rocky intertidal habitats at Slip Point, Observatory Point, and Neah Bay. Epibenthic crustaceans predominated in its rather simple prey spectrum (Fig. 10-14); gammarid amphipods (70.8% of the total IRI) and harpacticoid copepods (21.27%) were most important, and sphaeromatid isopods (Dynamenella sheareri) were less important.

Fluffy sculpin, Oligocottus snyderi. This fish occurred in greater abundance than saddleback sculpin but was generally confined to the same rocky intertidal habitats at Slip Point, Observatory Point, and Neah Bay; the cobble intertidal habitat at Twin Rivers also produced quite a few specimens. The overall prey spectrum of O. snyderi (Fig. 10-15) was markedly similar to that of O. rimensis (Fig. 10-14). Only the greater proportional numerical contribution by harpacticoid copepods altered the relative importance of the principal prey, gammarid amphipods, harpacticoid copepods, and sphaeromatid isopods. The species Hyale rubra was the only identifiable gammarid amphipod. Sphaeromatid isopods included Gnorimosphaeroma oregonensis, Exosphaeroma amplicauda, and Dynamenella sheareri. Algae (Ulotrichales), chitons (Polyplacophora), and valviferan isopods (Idoteidae) were also somewhat important because of their gravimetric contribution.

Manacled sculpin, Synchirus gilli. An adult captured during the Morse Creek beach-seine collections had consumed 13 harpacticoid copepods.

Cabezon, Scorpaenichthys marmoratus. A juvenile caught during beach seining at Port Williams had eaten nine caridean shrimp (75.00% of total number of prey, 96.52% of total biomass), two gammarid amphipods, and one caprellid amphipod.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA
PREDATOR 8831022401 - OLIGOCOTTUS MACULOSUS
(TIDEPOOL SCULPIN) ADJUSTED SAMPLE SIZE = 174



PREY ITEM	FREQ. OCCUR.	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	45.40	5.64	12.55	834.9	16.13
HARPACTICOIDA	40.80	75.13	8.66	3419.1	66.04
SPHAEROMATIDAE	22.41	3.28	17.11	457.0	8.83
POLYCHAETA	12.07	.91	11.82	153.7	2.97
CIRRIPEDIA	11.49	3.04	9.72	146.6	2.83
OSTRACODA	10.34	1.72	.10	18.7	.36
DIPTERA	8.62	1.55	.42	20.4	.39
TANAIDACEA-DIKONOPHORA	6.90	.43	.32	5.2	.10
ASELLOTA	6.32	.55	.65	7.6	.15
INSECTA	5.17	.58	.14	3.7	.07
HYALIDAE	4.02	.49	2.25	11.1	.21
UNIDENTIFIED	4.02	.49	1.66	8.7	.17
EUCARIDA-DECAPODA-BRACHYRHYNCH	3.45	.49	7.74	28.4	.55
GRAPSIDAE	2.30	.12	2.00	4.9	.09
ISAEIDAE	2.30	.12	1.51	3.8	.07
CALANOIDA	2.30	1.22	.58	4.1	.08
PAGURIDAE	1.72	.09	2.23	4.0	.08
HIPPOLYTIDAE	1.72	.09	6.87	12.0	.23
ARCHAEOGASTROPODA	1.15	.06	3.77	4.4	.09
TELEOSTEI	1.15	.06	2.26	2.7	.05

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION WITH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.57	.09	.47
SHANNON-WEINER DIVERSITY	1.80	3.96	1.72
EVENNESS INDEX	.32	.71	.31

Fig.10-13. IRI prey spectrum of tidepool sculpin from Strait of Juan de Fuca, 1978.

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```
INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78, STATION ALSTA
                    PREDATOR  8831022402 - OLIGOCOTTUS RIMENSIS
                 (SADDLEBACK SCULPIN  )  ADJUSTED SAMPLE SIZE =  26
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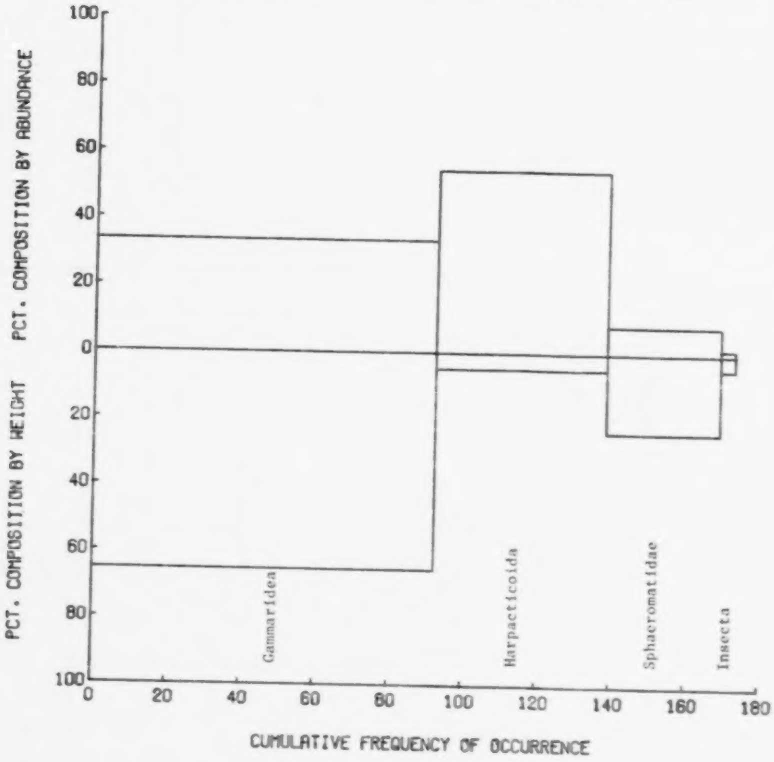

```
          PREY ITEM                    FREQ   NUM.   GRAV.   PREY     PERCENT
                                       OCCUR  COMP.  COMP.   I.R.I.   TOTAL IRI
------------------------------------   -----  -----  -----   ------   ---------

GAMMARIDEA
HARPACTICOIDA                          92.31  33.47  65.37   9123.4     70.90
SPHAEROMATIDAE                         46.15  54.55   4.84   2741.0     21.27
INSECTA                                30.77   8.26  23.72    984.0      7.64
                                        3.85   1.65   4.45     23.5       .18

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

     PERCENT DOMINANCE INDEX                  .42    .49                .55
     SHANNON-WEINER DIVERSITY                1.56   1.42               1.14
     EVENNESS INDEX                           .49    .45                .36
```

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Fig.10-14. IRI prey spectrum of saddleback sculpin from Strait of Juan de Fuca, 1978.

```
INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78, STATION ALSTA
                    PREDATOR  8831022403 - OLIGOCOTTUS SNYDERI
                  (FLUFFY SCULPIN       )   ADJUSTED SAMPLE SIZE =  93
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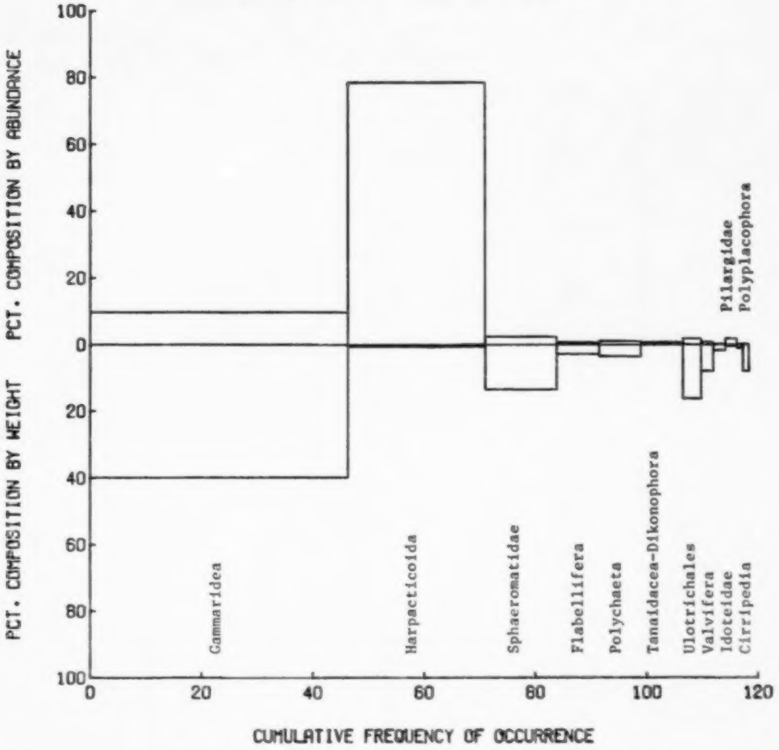

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                                   FREQ   NUM.   GRAV.   PREY    PERCENT
        PREY ITEM                  OCCUR  COMP.  COMP.   I.R.I.  TOTAL IRI
---------------------------        -----  -----  -----   ------  ---------

GAMMARIDEA                         46.24   9.76  39.67   2294.6    49.51
HARPACTICOIDA                      24.73  78.51    .63   1957.1    42.23
SPHAEROMATIDAE                     12.90   2.31  13.51    204.2     4.41
FLABELLIFERA                        7.53    .69   2.89     26.9      .58
POLYCHAETA                          7.53   1.03   3.60     34.8      .75
TANAIDACEA-DIKONOPHORA              7.53    .68    .05      5.5      .12
ULOTRICHALES                        3.23   1.80  16.31     58.4     1.26
VALVIFERA                           2.15    .77   7.98     18.8      .41
IDOTEIDAE                           2.15    .17   1.72      4.1      .09
CIRRIPEDIA                          2.15   1.71    .50      4.8      .10
PILARGIDAE                          1.08    .09   1.06      1.3      .03
POLYPLACOPHORA                      1.08    .09   8.05      8.7      .19

  PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
  COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
  (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

     PERCENT DOMINANCE INDEX                 .63    .22                  .43
     SHANNON-WEINER DIVERSITY               1.39   2.79                 1.52
     EVENNESS INDEX                          .31    .63                  .34
```

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Fig. 10-15. IRI prey spectrum of fluffy sculpin from Strait of Juan de Fuca, 1978.

Roughback sculpin, Chitonotis pugetensis (juvenile). One juvenile from the Beckett Point beach-seine collections had eaten three hippolytid shrimp (76.25% of total prey biomass) and one cancrid crab.

Tadpole sculpin, Psychrolutes paradoxus. An adult from the Port Williams beach-seine collections had consumed two gammarid amphipods and one pandalid shrimp (94.12% of total prey biomass).

Warty poacher, Ocella verrucosa (juvenile). Mysids (50.00% of total prey numbers, 81.14% of total prey biomass) and gammarid amphipods (45.83% of total prey numbers, 17.98% of total prey biomass) were the most important component of the stomach contents of five juveniles caught in beach-seine collections at Dungeness Spit and Twin Rivers.

Tubenose poacher, Pallasina barbata. This diminutive poacher appeared commonly in the beach-seine collections at Morse Creek, Port Williams, Beckett Point, and Twin Rivers. The prey spectrum from this sample (Fig.10 -16) is composed almost entirely of epibenthic organisms, principally gammarid amphipods (48.23% of total IRI) and mysids (37.38%), and secondarily caridean shrimp and harpacticoid copepods.

Ribbon snailfish, Liparis cyclopus. The stomach contents of an adult from an Observatory Point tidepool collection contained 20 gammarid amphipods (86.96% of total prey numbers, 19.43% of total prey biomass), but the majority of the prey biomass was contributed by a polychaete annelid (53.65%) and an unidentified decapod crustacean (26.83%).

Tidepool snailfish, Liparis florae. Intertidal collections at Morse Creek, Slip Point, and Observatory Point provided most of the specimens. Gammarid amphipods, 92.62% of the total IRI (Fig.10-17), appear to be a highly preferred prey. Harpacticoid copepods provided 30.54% of the total number of prey, but they and idoteid isopods (Idotea fewkesi) were less important.

Ringtail snailfish, Liparis rutteri. Two specimens were collected, one by beach seine at Twin Rivers and one from an intertidal collection at Observatory Point. One had fed upon mysids, and the other idoteid isopods. Both had consumed gammarid amphipods.

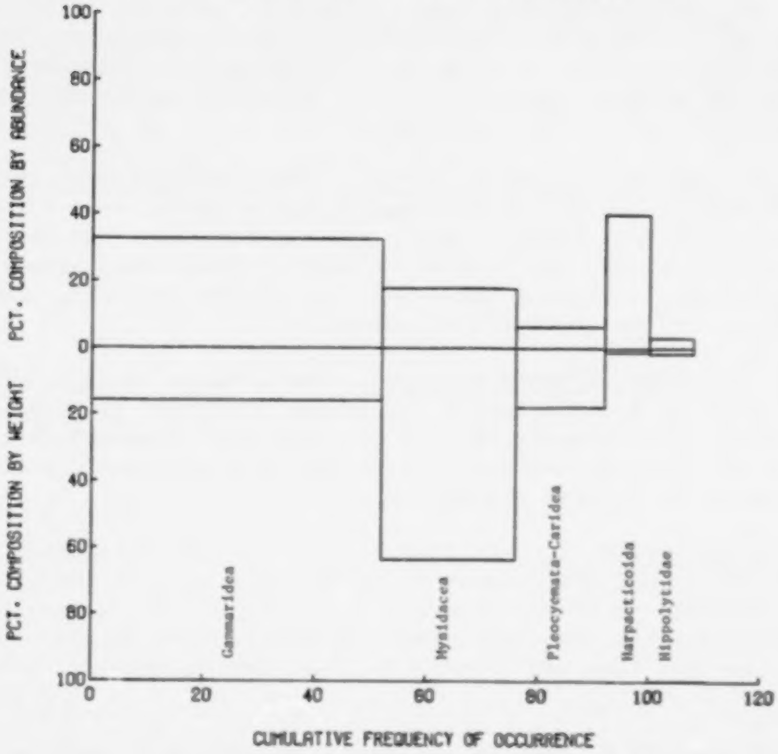
Kelp perch, Brachyistius frenatus (juvenile). Only beach-seine collections at Beckett Point provided specimens for stomach analysis. Only cyclopoid copepods were identifiable from the contents of the four fish with food in their stomachs.

Shiner perch, Cymatogaster aggregata. Of the 16 fish retained for stomach analyses, 15 originated from the Beckett Point beach-seine collections; 68.8% had empty stomachs. Tanaids were by far the prevalent food item in the stomach contents (96.15% of the total number of prey, 97.52% of the total prey biomass) and gammarid amphipods and several hippolytid shrimp provided only incidental contributions.

Striped seaperch, Embiotoca lateralis (juvenile). Juveniles were caught during beach seining at Morse Creek, Beckett Point, and Twin Rivers. Gammarid

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78, STATION ALSTA

PREDATOR 8831081101 - PALLASINA BARBATA
(TUBENOSE POACHER) ADJUSTED SAMPLE SIZE = 25



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                                   FREQ   NUM.   GRAV.   PREY     PERCENT
        PREY ITEM                  OCCUR  COMP.  COMP.   I.R.I.   TOTAL IRI
  ---------------------------      -----  -----  -----   ------   ---------

GAMMARIDEA                         52.00  32.63  15.89   2523.0     48.23
MYSIDACEA                          24.00  17.89  63.58   1955.3     37.34
PLEOCYEMATA-CARIDEA                16.00   6.32  17.74    385.5      7.37
HARPACTICOIDA                       8.00  40.01   1.13    329.1      6.29
HIPPOLYTIDAE                        8.00   3.16   1.62     38.2       .73

  (PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
  COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
  (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

     PERCENT DOMINANCE INDEX                 .30    .45                .38
     SHANNON-WEINER DIVERSITY               1.91   1.45               1.62
     EVENNESS INDEX                          .82    .62                .70
```

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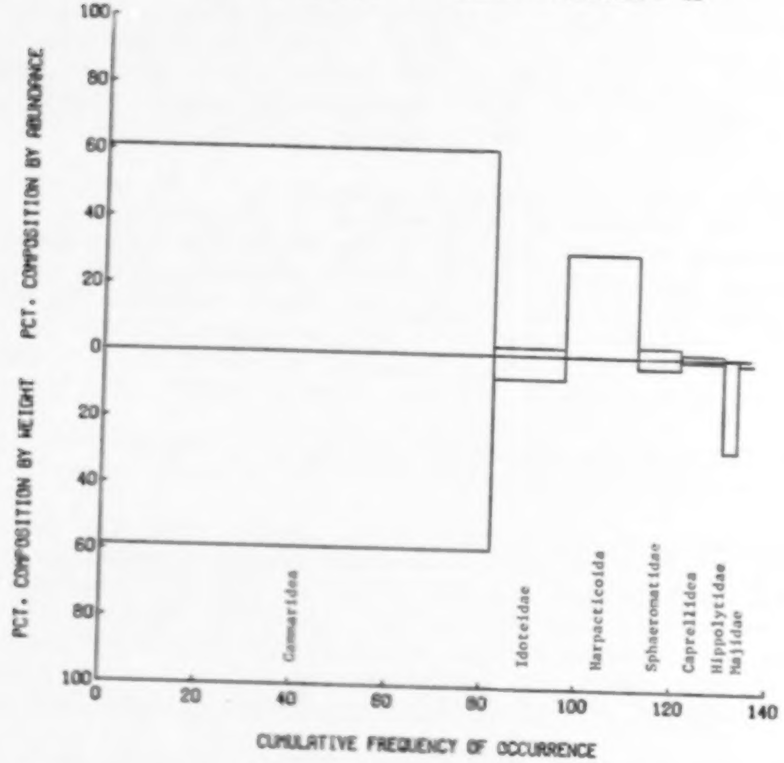
Fig. 10-16. IRI prey spectrum of tubenose poachers from Strait of Juan de Fuca, August 1978.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA
PREDATOR 8831090810 - LIPARIS FLORAE
(TIDEPOOL SNAILFISH) ADJUSTED SAMPLE SIZE = 33



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       PREY ITEM                  FREQ   NUM.   GRAV.   PREY    PERCENT
                                  OCCUR  COMP.  COMP.   I.R.I.  TOTAL IRI
-----------------------------     -----  -----  -----   ------  ---------
GAMMARIDEA
IDOTEIDAE                         81.82  61.67  54.75   9903.4    92.62
HARPACTICOIDA                     15.15   2.50   7.04    144.8     1.37
SPHAEROMATIDAE                    15.15  30.56    .09    464.1     4.38
CAPRELLIDEA                        9.09   3.04   3.25     57.1      .54
HIPPOLYTIDAE                       9.09   1.25    .87     19.3      .18
MAJIDAE                            3.03    .19  27.94     85.2      .81
                                   3.03    .14   1.62      5.5      .05
  PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
  COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
  (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

    PERCENT DOMINANCE INDEX                .47    .43
    SHANNON-WEINER DIVERSITY              1.44   1.40               .86
    EVENNESS INDEX                         .41    .45               .51
                                                                    .14
```

Fig. 10-17. IRI prey spectrum of tidepool sculpin from Strait of Juan de Fuca, 1978.

amphipods (76.86% of the total number of prey, 96.53% of the total prey biomass) were the most important prey organism, followed by cyclopoid copepods (20.66% of the total numbers of prey), sphaeromatid isopods (3.05% of the total prey biomass), and mysids (1.65% of the total numbers of prey).

Pile perch, Rhacochilus vacca (juvenile). Like most of the embiotocids, this species was captured by beach seine at Beckett Point; all those examined were juveniles. Gastropod molluscs, perhaps littorine snails, completely dominated the contents of the seven stomachs which were examined; 71.43% of the stomachs contained them, 98.72% of the total number of prey were gastropods, and they composed 95.77% of the total prey biomass. Tanaids, gammarid amphipods, and pagurid crabs constituted the incidental prey items.

Redtail surfperch, Amphisticus rhodoterus. The majority (96%) were juveniles and appeared to be restricted to the western strait, where they were collected by beach seine at Kydaka Beach and Twin Rivers. The prey spectrum was dominated by two epibenthic crustacean taxa--sphaeromatid isopods (Gnorimosphaeroma oregonensis), which accounted for 70.33% of the total IRI, and gammarid amphipods (Atylus tridens), which accounted for 25.12%. Cancrid crabs (juvenile Cancer magister) provided 17.7% of the total prey biomass and bivalves 5.5%, but they were not common prey items.

Pacific sandfish, Trichodon trichodon (juvenile). One juvenile from a beach-seine collection at Kydaka Beach had an empty stomach.

High cockscomb, Anoplarchus purpurescens. This species was commonly collected at all intertidal collections sites. Numerically, barnacle larvae dominated the prey spectrum (Fig. 10-18) at 66.56% of the total number of prey items, but overall accounted for only 17.94% of the total IRI. Polychaete annelids were consistently the most important prey taxon, providing 46.61% of the total IRI. Other important prey were harpacticoid copepods and gammarid amphipods (Melita desdichata, Aoroides columbiae, Parallorchestes ochotensis).

Ribbon prickleback, Phytichthys chirus. This species occurred in intertidal collections at Slip Point, Observatory Point, Morse Creek, and Tatoosh Island. The diet spectrum (Fig. 10-19) was rather diverse considering the sample size, the fifth highest in prey abundance and the fifth highest in prey biomass. Gammarid amphipods (Atylus tridens) were the only prey which stood out as a dominant food item, 78.79% of the total IRI. The remaining prey composed less than 10% of the total IRI; important taxa in decreasing order of percent total IRI were polychaete annelids, algae (Ulotrichales and Rhodophyta), asellotan isopods, and plant material (Potamogetonaceae).

Black prickleback, Xiphister atropurpureus. Black prickleback have approximately the same distribution as ribbon prickleback. The prey spectrum (Fig. 10-20) is similarly diverse, and in fact is the second most diverse spectrum based on percent total IRI (H' = 2.54 as compared with H' = 3.06 for padded sculpin). Sphaeromatid isopods (both Gnorimosphaeroma oregonensis and Dynamenella sheareri), 40.04% of the total IRI; gammarid amphipods (Atylus tridens), 25.66%; and sabellarid polychaetes, 10.18%, were the prey taxa of primary importance. Other polychaetes, harpacticoid copepods, and serpulid polychaetes were of secondary importance.

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INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA
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        (HIGH COCKSCOMB      )  ADJUSTED SAMPLE SIZE =  53
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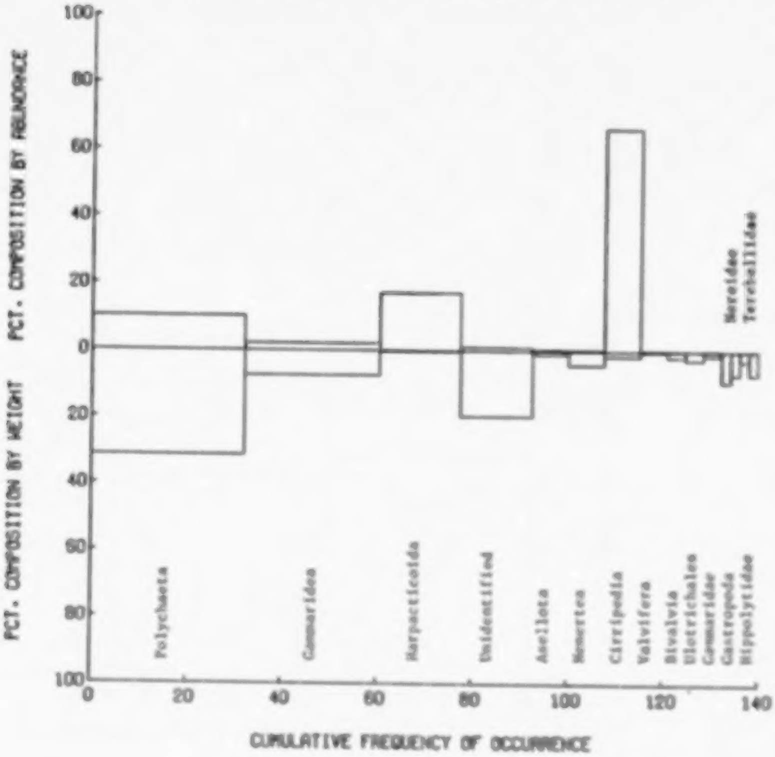

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                                   FREQ   NUM.   GRAV.   PREY    PERCENT
       PREY ITEM                   OCCUR  COMP.  COMP.   I.R.I.  TOTAL IRI
 --------------------------       -----  -----  -----   ------  ---------

 POLYCHAETA                       32.08  10.11  31.49   1333.9    46.61
 GAMMARIDEA                       24.53   2.07   7.59    278.0     9.67
 HARPACTICOIDA                    16.98  17.30    .26    297.0    10.41
 UNIDENTIFIED                     15.09   1.18  19.79    315.3    11.02
 ASELLOTA                          7.55    .45    .93     10.4      .36
 NEMERTEA                          7.55    .39   4.26     35.1     1.23
 CIRRIPEDIA                        7.55  66.54   1.49    513.5    17.96
 VALVIFERA                         5.66    .26    .16      2.4      .08
 BIVALVIA                          3.77    .13   1.73      7.0      .26
 ULOTRICHALES                      3.77    .13   2.65     10.5      .37
 GAMMARIDAE                        3.77    .19   1.19      5.2      .18
 GASTROPODA                        1.89    .06   9.29     17.6      .62
 HIPPOLYTIDAE                      1.89    .06   7.03     13.4      .47
 NEREIDAE                          1.89    .06   2.92      5.6      .20
 TEREBELLIDAE                      1.89    .06   6.88     13.1      .46

  PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
  COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
  (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

     PERCENT DOMINANCE INDEX                .68    .17                 .28
     SHANNON-WEINER DIVERSITY              1.81   3.17                2.33
     EVENNESS INDEX                         .35    .69                 .51
```

Fig. 10-18. IRI prey spectrum of high cockscomb from Strait of Juan de Fuca, 1978.

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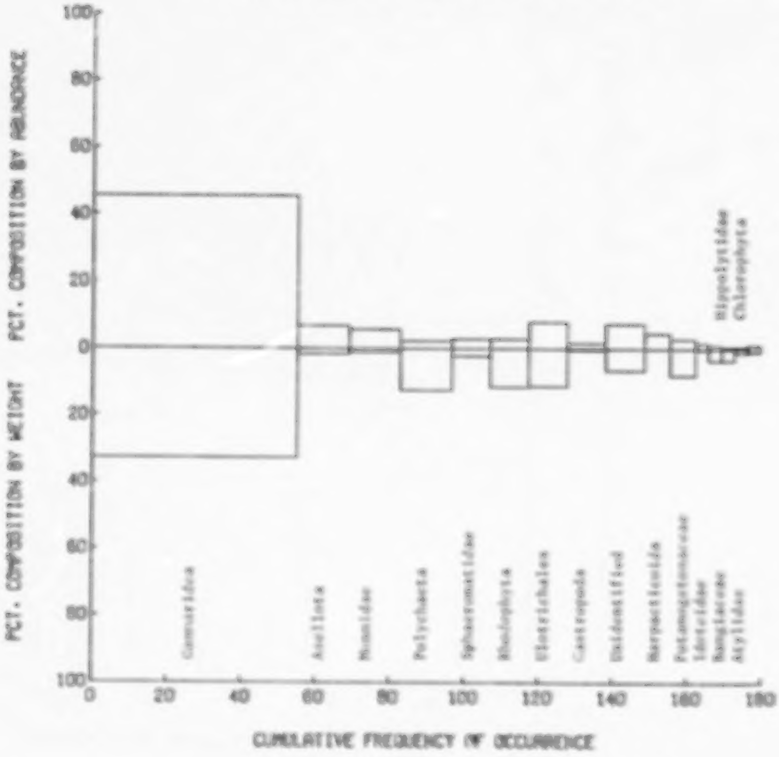
INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA
PREDATOR 8842121001 - PHYTICHTHYS CHIRUS
(RIBBON PRICKLEBACK) ADJUSTED SAMPLE SIZE = 29



PREY ITEM	FREQ. OCCUR.	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	55.17	45.45	32.41	4318.5	78.78
ASELLOTA	13.79	6.82	1.62	116.3	2.12
MYSIDAE	13.79	5.68	1.06	92.9	1.69
POLYCHAETA	13.79	2.27	12.61	205.3	3.74
SPHAEROMATIDAE	10.34	2.84	2.29	53.1	.97
RHODOPHYTA	10.34	2.84	11.54	148.7	2.71
ULOTRICHALES	10.34	7.95	11.35	199.6	3.64
GASTROPODA	10.34	1.70	.36	21.3	.39
UNIDENTIFIED	10.34	7.39	6.56	144.2	2.63
HARPACTICOIDA	6.90	4.55	.02	31.5	.57
POTAMOGETONACEAE	6.90	2.84	8.03	75.0	1.37
IDOTEIDAE	3.45	1.70	.23	6.7	.12
BANGIACEAE	3.45	1.14	3.56	16.2	.30
ATYLIDAE	3.45	.57	3.56	14.2	.26
HIPPOLYTIDAE	3.45	.57	1.15	5.9	.11
CHLOROPHYTA	3.45	1.14	.92	7.1	.13

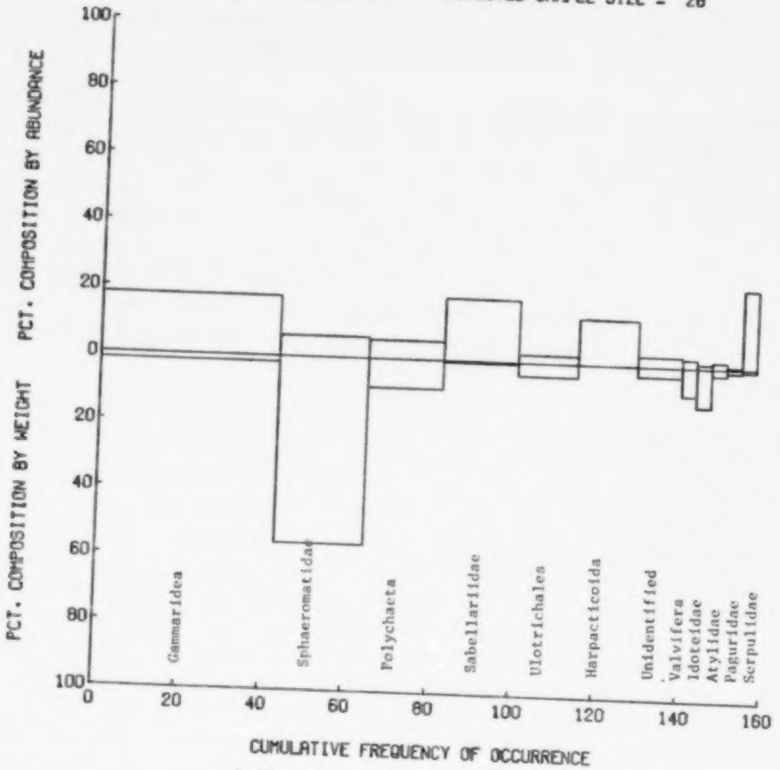
(PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.23	.16	.63
SHANNON-WEAVER DIVERSITY	3.12	3.16	1.47
EVENNESS INDEX	.66	.63	.32

Fig. 10-19. IRI prey spectrum of ribbon prickleback from Strait of Juan de Fuca, 1978.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA

PREDATOR 8842121401 - XIPHISTER ATROPURPUREUS
(BLACK PRICKLEBACK) ADJUSTED SAMPLE SIZE = 28



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        PREY ITEM                FREQ    NUM.    GRAV.    PREY     PERCENT
-----------------------------   OCCUR   COMP.   COMP.    I.R.I.   TOTAL IRI
                                -----   -----   -----    ------   ---------
GAMMARIDEA                      42.86   17.90    1.71     840.3     25.24
SPHAEROMATIDAE                  21.43    5.17   56.04    1333.2     40.04
POLYCHAETA                      17.86    5.56    8.76     255.6      7.68
SABELLARIIDAE                   17.86   18.52     .47     339.0     10.19
ULOTRICHALES                    14.29    2.47    3.95      91.7      2.75
HARPACTICOIDA                   14.29   13.58     .02     194.3      5.84
UNIDENTIFIED                    10.71    3.09    3.02      65.5      1.97
VALVIFERA                        3.57    2.47    8.45      39.0      1.17
IDOTEIDAE                        3.57    1.23   11.74      46.5      1.40
ATYLIDAE                         3.57    1.85    2.10      14.1       .42
PAGURIDAE                        3.57     .62    1.13       6.3       .19
SERPULIDAE                       3.57   23.46     .77      86.5      2.60

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
(BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

  PERCENT DOMINANCE INDEX              .15     .35                 .25
  SHANNON-WEINER DIVERSITY            3.13    2.29                2.54
  EVENNESS INDEX                       .77     .56                 .62
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Fig.10-20. IRI prey spectrum of black prickleback from Strait of Juan de Fuca, 1978.

Rock prickleback, Xiphister mucosus. Rock prickleback had a general distribution among the intertidal collections similar to that of the black prickleback. Algae (Ulotrichales and unidentified) dominated the prey spectrum (Fig. 10-21), primarily because of the high biomass contribution (97.43%). Harpacticoid copepods and gammarid amphipods were the most abundant prey in the stomach contents whereas sphaeromatid isopods, important in the other stichaeids, was relatively insignificant.

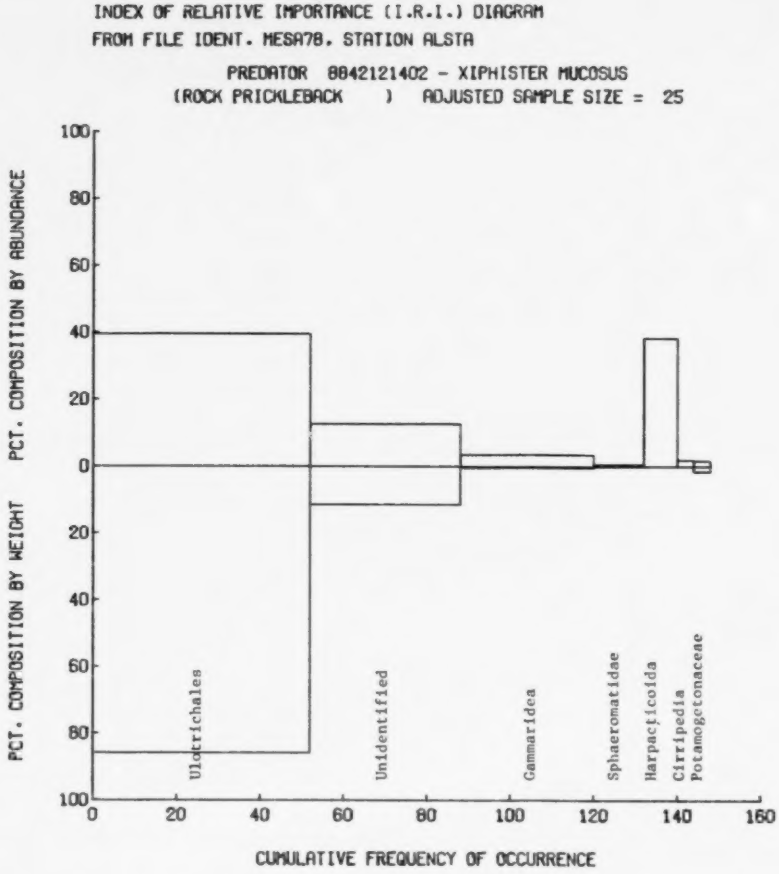
Penpoint gunnel, Apodichthys flavidus. Beach-seine collections in gravel-cobble habitats at Twin Rivers and Morse Creek and the sand-eelgrass habitat at Beckett Point and intertidal collections in rocky and cobble habitats yielded specimens. Gammarid amphipods were the most common prey (47.83% frequency of occurrence) and provided the highest proportion (45.05%) of the total prey biomass. Although not as common in the sample (26.09% frequency of occurrence), harpacticoid copepods were extremely abundant, composing 87.62% of the total prey abundance. Sphaeromatid isopods (including only identifiable *Gnorimosphaeroma oregonensis*) were less common but composed over 31% of the total prey biomass.

Crescent gunnel, Pholis laeta. Crescent gunnel appeared to be even more broadly distributed than penpoint gunnel; they were captured during both beach-seine and intertidal collections and were most common at Beckett Point, Slip Point, Morse Creek, and Twin Rivers. Because of their high contribution to the total number of prey items (61.16%), harpacticoid copepods provided the highest proportion of the total IRI, 51.04% (Fig. 10-22). Gammarid amphipods, however, occurred more often in the sample and made the second highest contribution to the prey biomass, thus accounting for almost 31% of the total IRI. Species of gammarid amphipods were, in order of numerical importance, *Hyale rubra*, *Parapleustes nautilus*, *Accedomoera vagor*, and *Aoroides columbiae*. Calanoid copepods, because of their abundance, and hippolytid shrimp and polychaete annelids, because of their high biomass, constituted secondary prey items. Sphaeromatid isopods (*Gnorimosphaeroma oregonensis* and *Dynamenella sheareri*) and caprellid amphipods were also important.

Saddleback gunnel, Pholis ornata. Three specimens were taken, two at Beckett Point and one at Twin Rivers, during beach-seine collections. Bivalves composed 70.97% of the total number of prey and 71.43% of the total prey biomass; several polychaetes, gammarid amphipods, and pieces of algae formed the remaining stomach contents.

Pacific sand lance, Ammodytes hexapterus (juvenile). Calanoid copepods were the only prey organisms found in the stomachs of four fish from Morse Creek and Kydaka Beach beach-seine collections.

Speckled sanddab, Citharichthys stigmaeus. These small flatfish were common in the beach-seine collections at Morse Creek, Dungeness Spit, Beckett Point, Kydaka Beach, and Twin Rivers. The relatively diverse prey spectrum (Fig. 10-23) was composed of epibenthic crustaceans--mysids (*Archaeomysis grebnitzki*), 47.53% of total IRI, gammarid amphipods, 22.67%, and cumaceans, 5.49%--and benthic holothuroideans (sea cucumbers), 14.63% of total IRI, and polychaete annelids, 1.79%. The "unidentified" category was primarily sand grains.



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
ULOTRICHALES	52.00	39.48	85.87	6518.1	82.96
UNIDENTIFIED	36.00	12.58	11.56	869.1	11.06
GAMMARIDEA	32.00	3.47	.41	124.1	1.58
SPHAEROMATIDAE	12.00	.65	.09	8.9	.11
HARPACTICOIDA	8.00	38.18	.01	305.5	3.89
CIRRIPEDIA	4.00	1.95	.01	7.8	.10
POTAMOGETONACEAE	4.00	1.74	1.45	12.8	.16

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.32	.75	.70
SHANNON-WEINER DIVERSITY	2.02	.73	.90
EVENNESS INDEX	.55	.20	.24

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Fig. 10-21. IRI prey spectrum of rock prickleback from Strait of Juan de Fuca, 1978.

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INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA
                    PREDATOR  8842130205 - PHOLIS LAETA
             (CRESCENT GUNNEL      )   ADJUSTED SAMPLE SIZE =  49
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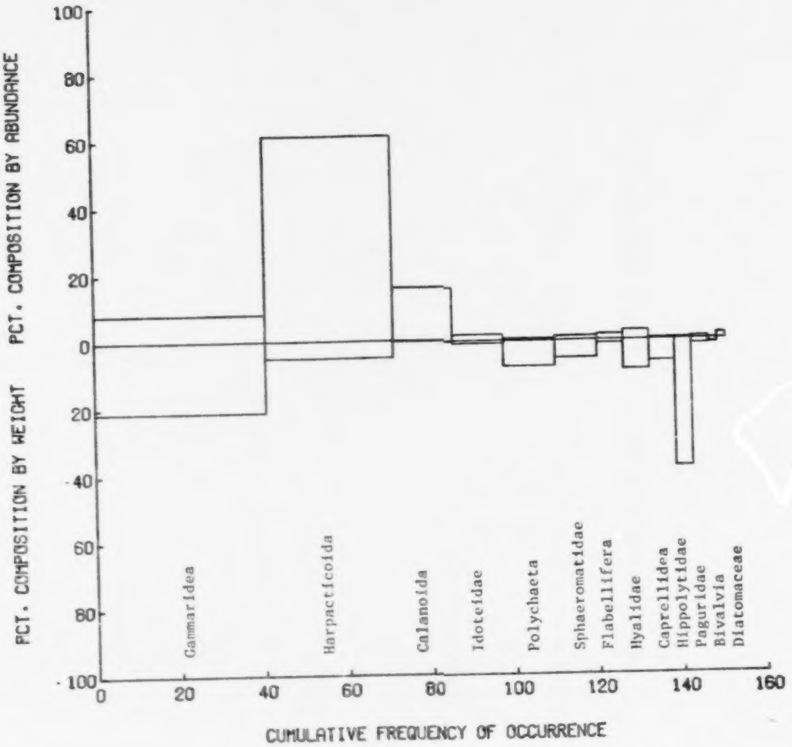

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                               FREQ   NUM.   GRAV.   PREY    PERCENT
        PREY ITEM              OCCUR  COMP.  COMP.   I.R.I.  TOTAL IRI
---------------------------    -----  -----  -----   ------  ---------

GAMMARIDEA                     40.82   8.04  21.26   1196.0    30.10
HARPACTICOIDA                  30.61  61.16   5.08   2027.7    51.04
CALANOIDA                      14.29  15.87    .17    229.2     5.77
IDOTEIDAE                      12.24   1.80    .79     31.7      .80
POLYCHAETA                     12.24    .63   7.73    102.5     2.58
SPHAEROMATIDAE                 10.20   1.16   5.34     66.4     1.67
FLABELLIFERA                    6.12   1.59   1.01     15.9      .40
HYALIDAE                        6.12   2.75   8.86     71.1     1.79
CAPRELLIDEA                     6.12    .42   6.46     42.2     1.06
HIPPOLYTIDAE                    4.08    .42  38.07    157.1     3.95
PAGURIDAE                       4.08    .74   1.46      9.0      .23
BIVALVIA                        2.04    .11   1.20      2.7      .07
DIATOMACEAE                     2.04   1.59    .02      3.3      .08

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

     PERCENT DOMINANCE INDEX             .41    .21                  .36
     SHANNON-WEINER DIVERSITY           2.14   2.82                 2.02
     EVENNESS INDEX                      .47    .61                  .44
```
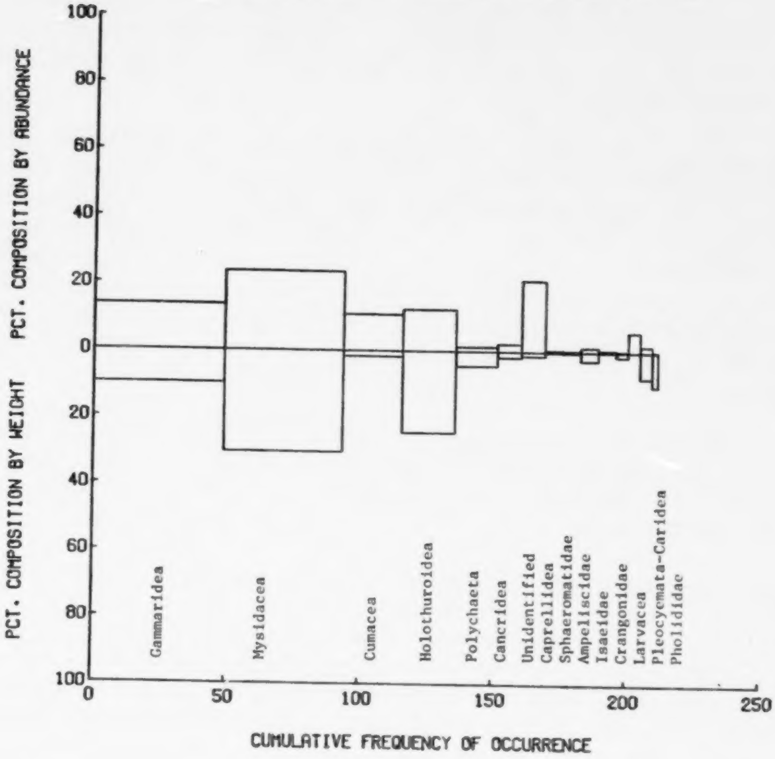

Fig.10-22. IRI prey spectrum of crescent gunnel from Strait of Juan de Fuca, 1978.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA
PREDATOR 8857030102 - CITHARICHTHYS STIGMAEUS
(SPECKLED SANDDAB) ADJUSTED SAMPLE SIZE = 45



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                                 FREQ   NUM.   GRAV.   PREY     PERCENT
         PREY ITEM               OCCUR  COMP.  COMP.   I.R.I.   TOTAL IRI
------------------------------   -----  -----  -----   ------   ---------

GAMMARIDEA                       48.89  13.53   9.87   1144.2     22.67
MYSIDACEA                        44.44  23.55  30.44   2399.2     47.53
CUMACEA                          22.22  10.63   1.64    276.9      5.49
HOLOTHUROIDEA                    20.00  12.31  24.62    738.7     14.63
POLYCHAETA                       15.56   1.35   4.47     90.6      1.79
CANCRIDEA                         8.89   2.30   1.83     36.7       .73
UNIDENTIFIED                      8.89  21.11   1.27    198.9      3.94
CAPRELLIDEA                       6.67    .54    .12      4.4       .09
SPHAEROMATIDAE                    6.67    .41    .26      4.4       .09
AMPELISCIDAE                      6.67   1.35   2.66     26.8       .53
ISAEIDAE                          6.67    .54    .06      4.0       .08
CRANGONIDAE                       4.44    .27   1.39      7.4       .15
LARVACEA                          4.44   5.82    .00     25.9       .51
PLEOCYEMATA-CARIDEA               4.44   1.76   7.86     42.8       .85
PHOLIDIDAE                        2.22    .14  10.48     23.6       .47

  PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
  COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
  (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

     PERCENT DOMINANCE INDEX              .15    .18                .30
     SHANNON-WEINER DIVERSITY            3.21   2.97               2.23
     EVENNESS INDEX                       .65    .60                .45
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Fig. 10-23. IRI prey spectrum of speckled sanddab from Strait of Juan de Fuca, August 1978.

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English sole, Parophrys vetulus (juvenile). Although more abundant than speckled sanddab, juvenile English sole were distributed similarly, maximum abundances occurring at Port Williams, Morse Creek, and Twin Rivers. The prey spectrum (Fig. 10-24) was rather evenly composed of epibenthic crustaceans--gammarid amphipods, 25.28% of the total IRI, tanaids, 12.49%, and cumaceans, 3.66%--and benthic polychaetes, 27.04%, and holothuroideans, 27.30%. Calanoid copepods appeared in only 9.7% of the stomachs but made up over 25% of the total number of prey items.

Starry flounder, Platichthys stellatus. This fairly large flatfish was most common at the western beach-seine sites along the strait, most of the specimens coming from Kydaka Beach and Twin Rivers. Holothuroideans, 55.26% of the total IRI, were the most important prey organism and accounted for 71.7% of the total numbers of prey. Cancrid crabs (Cancer magister) because of their large contribution (58.92%) to the total prey biomass were also important, with 36.57% of the total IRI. Polychaete annelids (2.49%), cumaceans (1.62%), gammarid amphipods (1.07%), and callianassid shrimp (1.14%) were secondary.

C-O sole, Pleuronichthys coenosus. Two fish from a beach-seine collection at Beckett Point had consumed mainly bivalves (80.0% of the total prey abundance, 95.85% of the total prey biomass), in addition to several polychaete annelids and a nemertean.

Sand sole, Psettichthys melanostictus (juvenile). This species was a prevalent component of the beach-seine catches at Morse Creek, Dungeness Spit, Twin Rivers, and Kydaka Beach. Mysids (Archaeomysis grebnitzki) constituted the main prey in the diet (Fig. 10-25), being well represented in the sample and providing high contributions to the total number of prey items and prey biomass (70.94% of the total IRI). Juvenile fishes, including juvenile flatfish, were the second most important prey, by contribution to the total prey biomass (59.11%). Gammarid amphipods, 9.84% of the total IRI, and larvaceans, 1.55%, were of secondary importance.

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INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA
          PREDATOR  8857041301 - PAROPHRYS VETULUS
     (ENGLISH SOLE        )  ADJUSTED SAMPLE SIZE =  72
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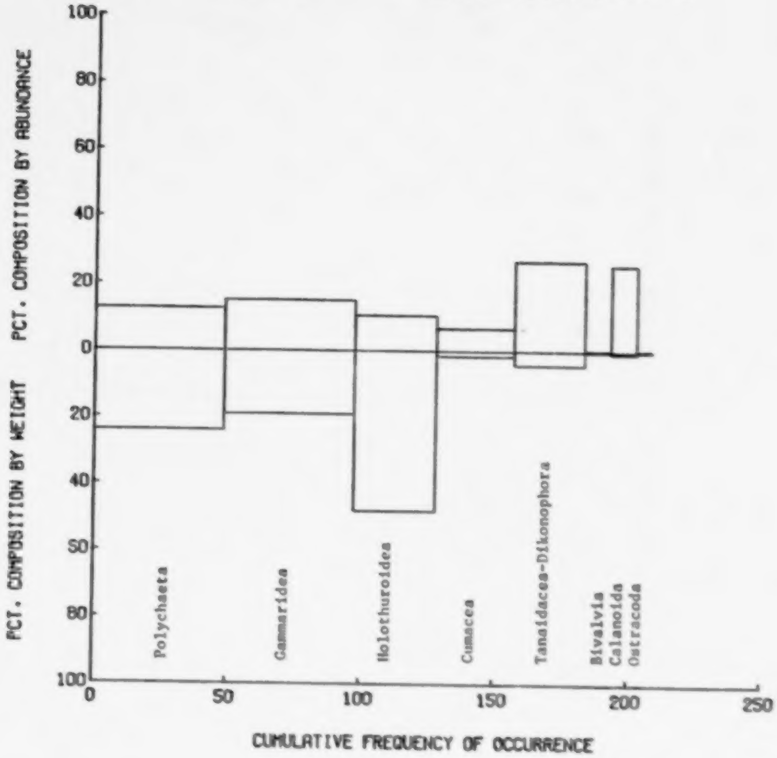

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                                     FREQ   NUM.   GRAV.   PREY     PERCENT
          PREY ITEM                 OCCUR  COMP.   COMP.  I.R.I.   TOTAL IRI
 ----------------------------       -----  -----   -----  ------   ---------

POLYCHAETA                          48.61  12.49   24.00  1774.0     27.04
GAMMARIDEA                          48.61  14.96   19.15  1658.1     25.28
HOLOTHUROIDEA                       30.56  10.49   48.14  1791.0     27.30
CUMACEA                             29.17   6.67    1.55   239.8      3.66
TANAIDACEA-DIKONOPHORA              26.39  26.82    4.22   819.2     12.49
BIVALVIA                             9.72    .36     .19     5.3       .08
CALANOIDA                            9.72  25.62     .69   255.7      3.90
OSTRACODA                            5.56    .31     .04     2.0       .03

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX                .19    .33                .23
      SHANNON-WEINER DIVERSITY              2.63   1.97               2.29
      EVENNESS INDEX                         .66    .49                .57
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best available copy.

Fig. 10-24. IRI prey spectrum of juvenile English sole from Strait of Juan de Fuca, August 1978.

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INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. MESA78. STATION ALSTA
            PREDATOR  8857041701 - PSETTICHTHYS MELANOSTICTUS
           (SAND SOLE           )   ADJUSTED SAMPLE SIZE =  69
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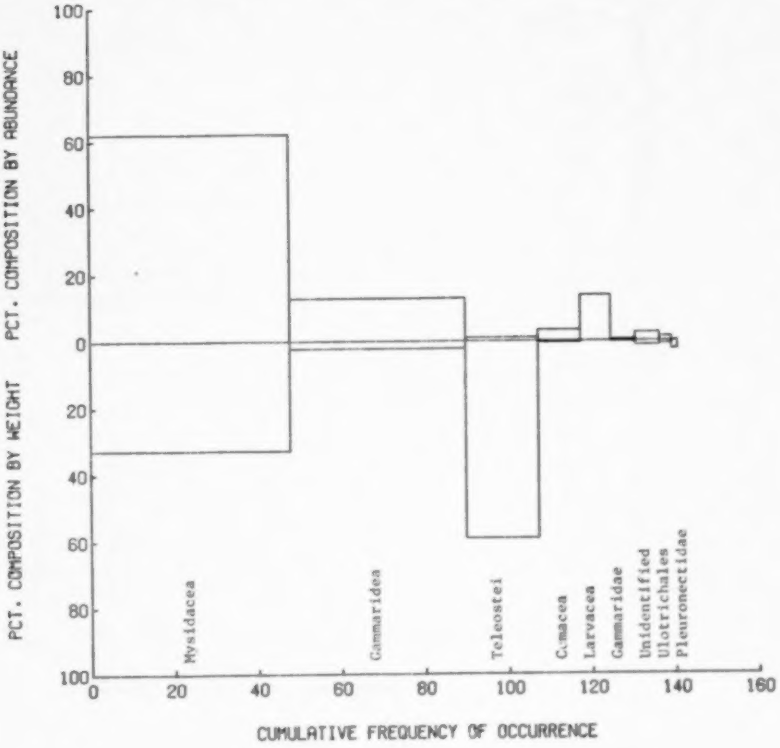

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                                       FREQ   NUM.   GRAV.  PREY    PERCENT
           PREY ITEM                   OCCUR  COMP.  COMP.  I.R.I.  TOTAL IRI
  ---------------------------          -----  -----  -----  ------  ---------

MYSIDACEA                              47.83  61.91  32.82  4530.4    70.96
GAMMARIDEA                             42.03  12.78   2.18   628.6     9.86
TELEOSTEI                              17.39   1.03  59.11  1045.8    16.38
CUMACEA                                10.14   3.23    .38    36.7      .57
LARVACEA                                7.25  13.56    .09    98.3     1.55
GAMMARIDAE                              5.80    .47    .20     3.9      .06
UNIDENTIFIED                            5.80   2.44   1.20    21.1      .33
ULOTRICHALES                            2.90   1.26    .78     5.9      .09
PLEURONECTIDAE                          1.45    .16   2.34     3.6      .06

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX                     .42    .46              .56
      SHANNON-WEINER DIVERSITY                   1.95   1.50             1.31
      EVENNESS INDEX                              .44    .34              .29
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Fig. 10-25. IRI prey spectrum of sand sole from Strait of Juan de Fuca, August 1978.

* GPO 797 - 540 1981